"A CONFUSION OF DERRICKS, CONCRETE MIXING MACHINES, BUCKET ELEVATORS ENORMOUS WOODEN BOXES, AND CURIOUS CYLINDRICAL OBJECTS. . . ."

See page 34.

SCIENTIFIC AMERICAN BOY SERIES

With the Men who do Things

BY
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Scientific American Boy at School,
Handy Man's Workshop and
Laboratory, etc.

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PREFACE

Every sound, healthy boy is endowed with a craving for information. It is with the purpose of satisfying that craving, insofar as it applies to engineering matters, that this book is written. Appreciating the timidity of some on approaching a subject with so formidable a name as "Engineering," the author has endeavored to lure them by dwelling largely on the romantic side of the work. Any boy with red blood in his veins will find plenty of interest and excitement in the deeds of men whose daily occupation is a battle with forces, beside which their own physical powers are puny. Much that is harrowing and gruesome might be introduced in the story, but the author has chosen to recount adventures that show courage, presence of mind, loyalty to comrades and devotion to duty, rather than accidents attributable to carelessness and stupidity.

In the preparation of this book the author's first act was to throw away the calendar. Manifestly all of the events described could not have taken place in any one summer. The fire on the bridge, described in Chapter XII. actually occurred on the Williamsburg Bridge during its construction in 1902; but if the story had been staged in that year, it could not have taken in other works, such as the aqueduct which is still under

construction, the Ambrose Channel which is only just completed, the big drydock finished last year and so on. Furthermore, the art of bridge building has advanced since that time, and wishing to have the engineering data up to date, the author has taken the liberty of staging the fire on the newer Manhattan Bridge.

After all, this is a work of fiction, yet the most remarkable of the adventures are based on fact. The story of the man in the aqueduct shaft, who fell out of a cage and landed uninjured on top, impossible though it may seem, is vouched for by the manager of one of the large contracting companies. Even "Danny Roach's" underground swim has a certain foundation in fact, for on one occasion, on some work near this city, rats with oakum tied to their tails, were dropped into a flooded caisson in the hope that they would crawl through the holes in the deck and thus stop the leaks; while on another occasion, a daring sand hog swam on his back under the burned deck of a caisson with scarcely any breathing space and stopped the leaks just as "Danny" did. The author is sorry that he has been unable to confirm the yarn of the man picked up by a dredge. The story came to him second-hand from a driver. Still there is no reason why such a strange adventure might not have taken place.

While the author has taken liberties with the narrative, he has been very careful to have the engineering data absolutely correct. He acknowledges a heavy

debt to the many engineers who have furnished him with information, loaned him photographs, and read his manuscript to make sure that it contained no technical errors. He is obligated to the Thompson-Starrett Company for permission to visit the Woolworth Building during construction; to Mr. Edwin S. Jarrett, Vice-President of the Foundation Company, for detailed information on foundation work, for the story of Danny's swim and for arranging an interview with Jackie Hughes, the man who was blown into the mud when his comrade was shot through the river bed; to Mr. George B. Walker for the description of a newspaper office; to Mr. George S. Rice for help with the chapter on tunneling under the East River; to Mr. George B. Fry for the story about plugging a leak with a human body, and for other adventures in the construction of the aqueduct; to Mr. D. L. Holbrook of the Otis Elevator Company for help with the chapter on elevators; to Mr. W. R. Bascome, who supplied nearly all of the photographs of bridge construction and explained the work in detail; to Mr. F. J. MacIsaac and his son, Donald MacIsaac, who were very courteous in guiding the author through the aqueduct and furnishing him with valuable information as well as photographs and diagrams; to Mr. Alfred D. Flinn, Department Engineer of the Board of Water Supply, for correcting the manuscript on that work; to Mr. H. N. Babcock and Mr. H. L. Potter, U. S. Army Engineers, in charge of

the Ambrose Channel; to Mr. H. F. Harris, U. S. Navy Engineer, in charge of the work on the drydock; to the U. S. Navy Department for permission to visit a submarine; to the New York Sanitary Utilization Company and Mr. Irving Blount for furnishing photographs and showing the author through the garbage disposal plant at Barren Island; to the New York Telephone Company for very courteously showing the author through a central station and supplying many photographs; and finally, to the Hamburg-American Line for supplying the photographs of the Diesel engine ship.

Many readers will recognize in "Bill" and "Jim" the two boys who did things in the "Scientific American Boy" and later in the "Scientific American Boy at School." Now we shall follow them in their experiences with "The Men Who Do Things."

A. Russell Bond.

New York, October, 1913.

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WITH THE MEN WHO DO THINGS.

CHAPTER I.

UNCLE ED'S WAGER.

"Now there is a boy for you," said Uncle Ed, handing over a school report to his fellow engineer, James Haldane McGreggor, "100 in Physics, 100 in Geometry. He is going to make a name for himself, that lad. I am going to send him to college next fall to take a course in engineering."

Dr. McGreggor glanced at the report critically. "Rather poor in some things I should say. Not a very creditable mark in German and only 75 in Latin."

"Languages always came hard to him."

"That's the way it is with boys who don't have to work for a living. They may be very good in things that come easy to them but they are too lazy to tackle the hard subjects. Why, when I was a boy I had to work hard all summer and do odd jobs the rest of the year to pay for my schooling. I tell you I appreciated my opportunities, because they were bought with the sweat of my own brow. You've made a big mistake to let your nephew waste his summers in camp."

"But look at what he did there. He developed into a first-class boy engineer. He built roads, made an excellent

survey of the locality, constructed bridges, log cabins, tree huts——"

"Mere play, mere play," interruted McGreggor, impatiently. "All boys are like that, but give them a really difficult task and they are lost. They graduate from school with high honors in mathematics, but when they strike college algebra, conic sections and calculus, they find that mathematics no longer comes easy to them and down they drop to the foot of the class. I tell you I know the type. Boys are ungrateful savages. The only way to make men of them is to rule them with a rod of iron and give them a bit of the thorny side of life when they are young so that they won't feel the pricks and scratches when they have to venture forth on their own hook. Why, the boys of to-day haven't any idea of the value of money. They don't know how hard it is to earn a dollar. Every spare penny I could save when I was a boy went toward the purchase of books—not story books, but real books on engineering. And my! how I appreciated those books. Hours and hours I pored over them by candle light in my attic room while my bones cried out for rest after the strenuous day's toil. Oh, I knew what a dollar meant. But your nephew here, I'll bet you a thousand dollars if he found himself in New York with $10 in his pocket, he'd blow it all in at Coney Island."

Uncle Ed was used to the blunt talk of his gruff associate, but a flush mounted to his temples at that last remark. However, he kept his temper. "Your advice on raising boys is rather trite, don't you think? It is all very well for some

boys, but I take exception to your statement that all boys are alike. I have seen as many varieties as there are diseases, and each one calls for its own specific treatment. Now I know Bill as well as if he were my own child; for haven't I been his father since his own parents died six years ago? I am not going to take you up on your foolish bet; I wouldn't tie up a thousand dollars in that senseless way; but I am going to put the boy to a test. I am going to give him that thousand dollars to use as he sees fit and we shall see what he does with it."

"What!" ejaculated Dr. McGreggor, "a thousand dollars to a mere boy! You will ruin him."

"Oh, no," answered Uncle Ed, "I know Bill. He will render a good account of every penny. If he isn't the boy I think he is, the sooner I find it out the better. I can then set him to work at something and save myself the cost of putting him through college."

"Of course if you give him a threat with the money he may be sensible enough not to squander it all."

"The money will be given him without strings of any sort. I shall have to be abroad all summer and he will be under no supervision whatsoever. I shall merely suggest that he take his chum, Jim, with him (those two are almost inseparable) and spend his summer seeing New York, also that he keep a diary."

" 'Seeing New York,' " quoted Dr. McGreggor with a laugh. "He'll do that all right."

CHAPTER II.

FIRST EVENING IN THE BIG CITY.

Of course neither Bill nor I knew anything of the wager in the foregoing chapter. Uncle Ed was a day out on the Atlantic when Bill received his letter apprising him of the bare fact that there was a thousand dollars to his credit in the Graham Bank, which he could spend in seeing New York with me, also that Uncle Ed wished to see a full account of his vacation experiences on his return in the fall.

On the following day the village postmaster handed me a letter. It was from Bill, of course. No one could mistake his scrawl. It began in his characteristic style:

"Hello, Jim:—Want you to chaperon me this summer in New York. We are to be all alone and may see whatever we choose of the old town. Uncle Ed has put up a thousand dollars to pay expenses. We'll have a dandy time. Will you come?"

Would I come! I didn't stop to read the letter twice but started for home at a pace that would have set a new world's record had there been any official around to time me. I burst into the front door and bounded upstairs to mother's room three steps at a time, making the old house tremble with my awkward stride. Outside her door I stopped abruptly and considered. A sickening thought seized me.

It was but a moment's pause, but in that moment the joy that had borne my spirits rocketing skyward, suddenly died and down they fell. Of course mother would not let me go.

Just then mother, alarmed at the noise, opened the door. The situation she took in at a glance and she gathered me into her arms as if I were a child—I, the big lumbering lad who could look down on her silvered head from the proud altitude of 5 feet 8¼ inches. Mother knew all about it, oddly enough, and raised not a single objection, but rejoiced with me over my good fortune. Uncle Ed, master general that he was, never made a move without attending to all the minutest details. He had written to father and mother and had persuaded them that certainly no harm, and possibly much good, might result from this unique summer's outing. Their consent was obtained before I could ask it, and all I had to do was to write Bill a formal acceptance and arrange for a meeting place.

The tiresome details of getting ready, packing my trunk, etc., form no vital part of my story and if the reader is half as anxious as I was, to get to our real experiences, we can well afford to skip the unimportant particulars that occupied me before I finally set foot in New York.

I could boast of having spent a day in New York once, but Bill had been in the big city at least half a dozen times and, naturally, he felt that he must do the piloting. He had already found a furnished room on a cross street somewhere in the Twenties for $6 a week and table board in the basement of a house three doors down, for $5 each. Sixteen

dollars per week! It seemed like rank extravagance but Bill said we couldn't possibly do it any cheaper.

It was after six when we reached our quarters and we lost no time prinking for dinner. It seemed like my first day in boarding-school as we walked into the dining-room and waited awkwardly for the waitress to seat us at one of the two long tables. When I got over my embarrassment sufficiently to take a survey of my surroundings I was surprised to find that the whole dining-room was not staring at me. After that I managed to compose myself and really ate a hearty dinner. Bill did not seem at all abashed and entered into quite a lively conversation with the little old lady at the end of the table.

When we got back to our room I found that my trunk had arrived. By the time it was unpacked and my things stowed away it had grown quite dark. We strolled out then to see the busy old town by lamp-light.

We had not gone far when the shriek of a fire whistle rose above the din of street noises and a moment later the fire apparatus swung around the corner and down the avenue at a map gallop, trailing fire and black smoke. It was like red flannel to a bullfrog. The bait was too much for us. We lit out after it. Why was no one else running to the fire? Bother the crowd, anyway. Everyone got in our way. How could we keep the engine in sight at that pace? A hook and ladder passed us, then a tower; presently a hose wagon, closely followed by another engine. We ran a mile and still the apparatus kept passing us.

"Must be some fire," panted Bill, "but I don't see any blaze. Guess it's miles off."

"Don't give up yet. I am going to keep on till I get there, even if I have to run ten miles."

We started off again and presently found ourselves down in City Hall Park, nearly two miles from home with still no engines in sight; but an occasional whistle told us that the fire could not be far off. A few blocks further and we came upon the first of the engines panting away down a dark side street belching forth volumes of smoke that obscured the dim street lamps. Fire engines were all around, down every side street. There must have been 20 or 30, each one pouring forth clouds of black soot. Now and then they tooted a call for the fuel wagon.

But where was the fire? We followed a hose line down a narrow street that did not seem to be much more than an alley; it certainly was not wide enough for two teams to pass. Through a rift in the smoke clouds I could see the tall buildings on either side rising until they almost met overhead. A policeman halted us at the foot of the alley and turned us back. We ran around the next block and were stopped again. At the third attempt we managed to get into position to see the fire. There was quite a crowd there watching the operations. The fire was not much to see, just smoke, smoke everywhere, through which filtered the beam of a searchlight directing the movements of the fire fighters. It was a building about eight stories high that was burning and it appeared to us that the fire was getting

beyond control, for suddenly there was a big burst of flame. The spectacle was magnificent and full of intense excitement to boys with red blood in their veins. We could see the firemen running around. Some were wielding their axes. Three men were hanging to a writhing hose, and they had all they could do to handle it. We realized the power of the water, for we were standing on a line of hose ourselves and we could feel it swell up under us. In the foreground was the tower reaching up some 60 feet from the ground and pouring a steady stream upon the fire from its high vantage point. The stream was evidently directed by a man on the truck below. Suddenly there was a warning cry above the din and racket. The men ran for shelter and the entire front of the building fell forward, burying the tower and an engine near by. An instant later there was a burst of water that threw Bill and myself to the ground. The hose had given away directly beneath us, simply drenching us from head to foot.

"Guess I have had enough," I spluttered. "where's home?"

"Eleven o'clock already," said Bill, looking at his watch. "The folks will all be abed and we haven't any key."

It looked pretty black. Two poor waifs drenched to the skin and destined to walk the streets all night. But despite the lateness of the hour New York seemed surprisingly wide awake, and when we reached our lodgings the landlady promptly admitted us without a word of reproof, though she looked askance at our bedraggled clothing.

FIGHTING A SPECTACULAR BLAZE IN LOWER NEW YORK.

FIVE HUNDRED FEET ABOVE BROADWAY.

CHAPTER III.

THE "RUBBER NECK" AUTO.

"WELL, what shall we see first?" asked Bill as we stowed away the coffee and "ham and."

"This is a great day for Coney Island," I replied, "and the Hippodrome, I want to take that in, and then there is the——What's the matter?" The withering scorn on Bill's face halted me.

"I thought better of you than that, Jim. Do you suppose Uncle Ed gave us a thousand dollars to spend on shows?"

I felt decidedly humiliated and badly nettled by his manner. "But I thought we were to see New York."

"Look here, Jim, there is more to New York than shows. What would Uncle Ed think if we started our diary with a description of Coney Island?"

"Our diary?"

"Yes, didn't I tell you we had to write an account of everything we do?"

"Oh, I see," said I, with all the sarcasm I could muster. "So you would rather go to Coney Island, too, if it were not for the diary."

"Oh, come off, Jim. What's the use of starting out with a quarrel. Uncle Ed would not kick if we spent every cent in a penny arcade, but I have a notion that he expects more

of us than that. Now I should like to see how they are building those tunnels under the river and the bridges over them, and what's more I know you would, too. Then there is the Navy Yard and the power stations and a hundred other sights."

"If you know what you want to see why did you ask me about it?" I returned, still irritated at his rebuke.

"Say, but you are touchy, Jim. I haven't made any plans yet because I thought we could make them out together. As long as Uncle Ed deposited the money in my name I think I shall have to be the treasurer of this association, and since you have always been handier than I with the pen I suggest that you hold the office of recording secretary. As for president, vice-president and the rest of the official positions, we can share those honors together. Is that agreeable to you, Pard?"

"Quite," I answered. "As long as you hold the purse strings it is very evident that I shall have to do as you say. Just what are your plans for the day?"

"Let us start with a general survey of the city. Suppose we get aboard a 'rubber-neck' auto and make a tour of the town so as to get acquainted with the principal points of interest."

"All right, Bill. I am agreeable."

After inquiring at a hotel where sight-seeing cars started from, eventually we found one which was due to begin its trip down town in five minutes. It was a very novel experience to me and to Bill too, for although he had seen the city

on several occasions, his visits had always been very brief and really he knew scarcely any more about the town that I did. We were all eyes, and we absorbed every nasal word that the megaphone man called out. When we got down to the tall buildings we were gaping like country gawks, particularly as we came alongside the new Manhattan Syndicate Building, whose skeleton of steel already reached 500 feet in the air. The funny thing about it was that the walls were not built from the ground up, but started from about the fifth floor; below that there was nothing but open steel work. Even when we were blocks away we had to crane our necks to see the top of the building. As we came nearer we could hear the tr-r-r-r- of the pneumatic rivetting hammers that sounded like locusts on a hot day.

"And those iron workers," recited the megaphone man, "have no more fear of falling than a sparrow. They will run along a beam only six inches wide like a squirrel on a telephone cable, and leap from one perch to another when a single misstep, the slightest misjudgment, the falter of an eye would mean a fearful plunge of 500 feet, fifteen seconds of awful suspense before crashing to the pavement, with a velocity ten times that of an express train!"

Up on the very top of a post that projected 25 feet above the rest of the structure I could see a man standing and waiting for a beam that was slowly swung toward him by a derrick. A sickening feeling seized me, my knees grew weak, and I shrank into a huddle of fright as he reached far out for the beam. My nerves were at such a tension that

when Bill nudged me I fairly bellowed: "What's the matter?"

"Say, the old duffer is a fraud," he said.

"What do you mean?"

"He is simply trying to make a sensation but he has mistaken his audience this time."

"Who, the iron worker?" I asked in bewilderment.

"No, no, the megaphone howler. His mathematics are away off and he thinks he can fool us. Why it would not take six seconds for a body to drop 500 feet. See here are my figures." He showed me the following formulae:

$$\text{Time} = \frac{\sqrt{\text{Space fallen through}}}{4.01};$$

$$\text{Velocity} = \frac{2 \times \text{space}}{\text{Time}}.$$

"The velocity figures to only 179 feet per second, or less than 125 miles an hour."

"Well, that would be enough to jar even your head if you should happen to land on it," I remarked.

"Certainly," said Bill, missing the point; "it is bad enough as it stands without any exaggeration. I am going to expose that fellow."

In the meantime the megaphone man had seen Bill figuring and covering him with his horn he said: "Don't butt in, young feller, I know what I am talking about. If I didn't double up the figures they wouldn't like it." And he gave us a knowing wink.

This was more than Bill could grasp. He always took things so literally and was such a stickler for the truth. "Shucks," he said, when the ride was over, "I couldn't trust a thing that fellow had to say. We will have to go all over the ground ourselves and verify his statements. Let us go down to that building and find out something about it. It would make a good subject to start the diary."

Immediately after luncheon we set out for the Manhattan Syndicate Building. When we got there we found a big crowd of spectators standing around and gazing skyward. Suspended by a thread 200 feet above them was a section of steel pipe that looked rather large, how big it was I did not realize until I paced one of the sections lying on the ground. It was fully 25 feet long and almost big enough for a horse to walk through. But there was that section dangling uncertainly above the heads of hundreds of people on cables that looked as frail as the threads of a spider web, while standing on the pulley block a veritable pigmy above the enormous steel cylinder, was a man holding to the center rope and directing operations while the ropes on either side of him were running up or down at different speeds. We watched him as he was carried up until he had to stoop to avoid the boom of the derrick at the top of the building. Then the boom was swung up, drawing the cylinder into the building and out of sight.

"Come on, Bill," I said, "let's go up and see what they are going to do with it."

CHAPTER IV.

FIVE HUNDRED FEET ABOVE BROADWAY.

We walked in what appeared to be the main entrance on Broadway. No one stopped us and we wandered about rather aimlessly. Here and there were busy groups of men. Though we were on the street level we could look down at one place about four stories. There was an engine room below us and a place where they were mixing mortar, putting it in wheelbarrows, and then shooting it up, wheelbarrows and all, to the upper floors, in elevators that moved at terrific speed.

"I wonder where the passenger elevator is," said Bill.

"I guess that is it," I replied, pointing to a ladder.

"Looks good enough for me," he rejoined. "It leads upward, anyway."

It was a broad double ladder, so arranged that one could go up while another went down. We raced up the ladder side by side and reached the floor above, neck and neck, all out of breath.

"Say, how many stories of this are there?" I asked.

"I counted thirty-nine from the street."

"Well, excuse me. If I've got to climb thirty-nine ladders like this I resign right here. There must be an elevator somewhere."

"There is one over there," exclaimed Bill, "and the car is just going up."

We ran over and jumped aboard. A man hailed us on the way, but we did not stop to answer him. The gate of the elevator shaft was slammed shut and we were off before he could ask any questions. The elevator was a large wooden box, big enough for about 15 men to squeeze into and with no door to it. As we were the last aboard we had the pleasure of standing at the very edge of this open side, shrinking back as far as we could for fear of striking the door frames of the shaft as we sped past the successive landings. The men in the elevator looked at us curiously, but no one challenged us. At the twenty-eighth floor the elevator stopped and we all got out. The floors were laid and there did not seem to be anything very exciting about our adventure so far. No walls were up as yet, but the outside girders were so deep all around the floor that they formed a sort of low parapet which kept a fellow from feeling that he was going to fall off when he went to the edge of the building.

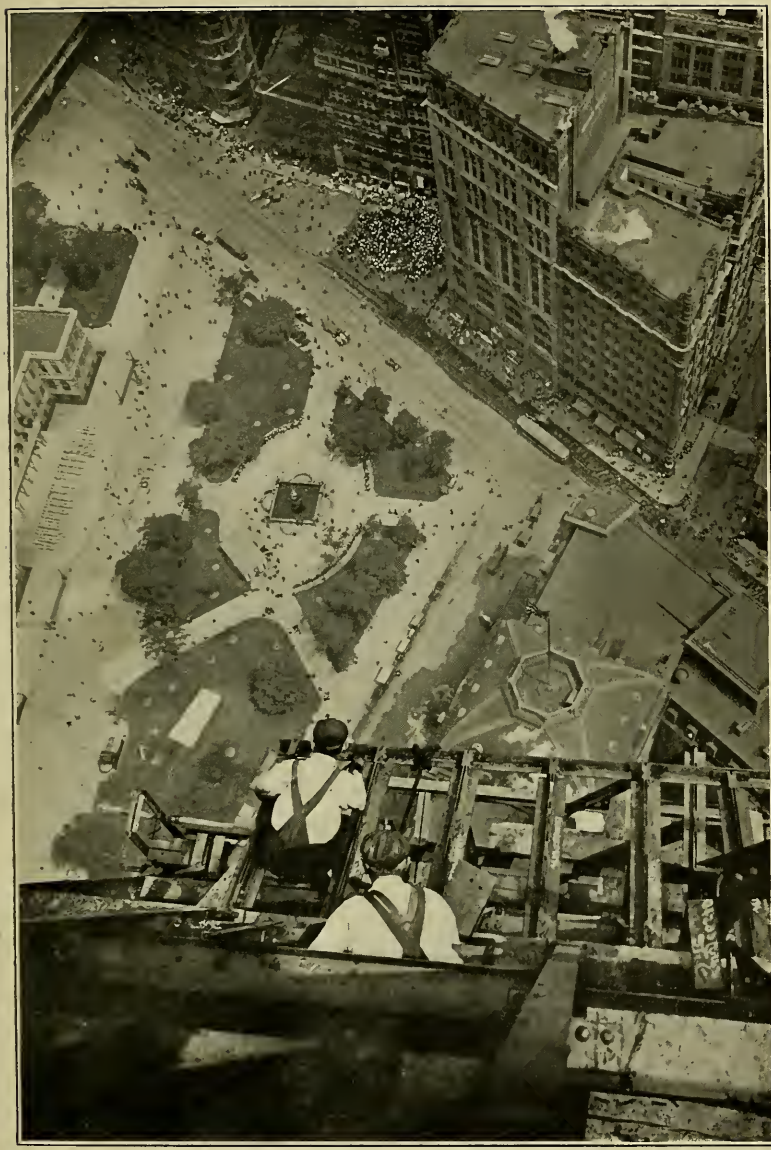
Projecting from the girder about ten feet apart were brackets from which was suspended a scaffold seven stories below where men were at work on the walls. Below that was Broadway filled with animated little specks, each tiny man no doubt fully conscious of his own importance. We could look down at one side on the spire of a church and I remember seeing a sparrow fly out of a chink in the steeple. I could look down with contempt upon the bird from this

loftier dwelling. How flat everything looked, yet the horizon was on a level with my eyes. I could easily trace the Hudson River from the Palisades to Governor's Island where it joined the East River, broadened out into the Upper Bay, squeezed through the Narrows, and then spread out into the Lower Bay. Off to the south the Atlantic Highlands showed clearly, and the Orange Mountains formed a ragged horizon to the west. The day was superb for long-distance seeing. There was not a cloud in the sky, not a trace of haze in the air.

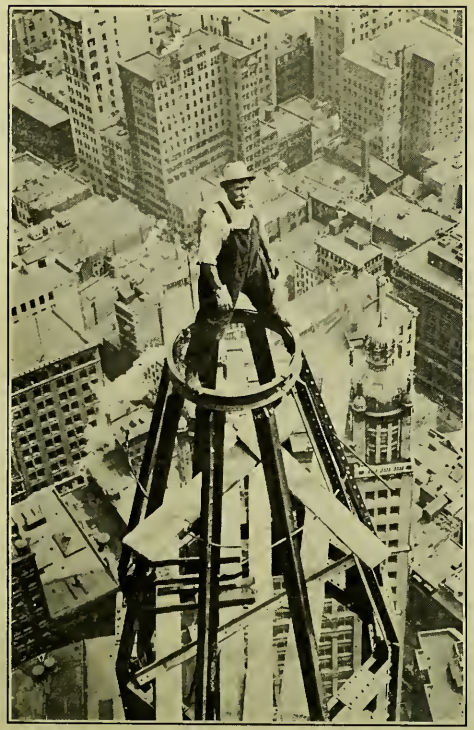
"Gee, but I wish I had brought my camera," shouted Bill, above the racket of the rivetting hammers.

"Yes, and I wish I had brought a cap. This blamed straw hat won't stay on." The wind was blowing a veritable gale. In the streets it was bad enough, but here there was no protection from it, and it swept by us at something like 50 miles an hour. I noticed that the men did not seem to have any trouble. Those who wore caps turned them like aviators, front for back, with the peak pointed up, so that the wind could not lift them, and tear them off their heads.

"Well, we had better proceed with our investigations, Bill," I said. "There is no use dreaming here all day." We spied a stairway near the elevator, which we mounted. The thirty-first story looked so like the thirtieth that we did not linger but went on up to the thirty-second. Here a gang of archmen were putting in the floor arches. I was astonished to find that the "arches" were perfectly flat and made of hollow tiles. A platform of planks was hung from the



HOW CITY HALL LOOKS TO THE STEEL CONSTRUCTION MAN.



FINISHING THE TOP OF A TOWER.

WAITING TO RECEIVE A BEAM.

beams to support the tiles until they were all set in place, as shown in Fig. 1. In the center of the arch a wedge-shaped tile served as a key to keep the floor from caving in. It was impossible for the tiles to be pushed through without spreading the steel floor beams apart.

There were no treads on the stairway leading to the next floor and so we had to hunt for a ladder. To reach the ladder we were obliged to pass an open shaft with no rail around it. It seemed to run all the way to the ground floor. We walked along a plank which lay at the foot of a high

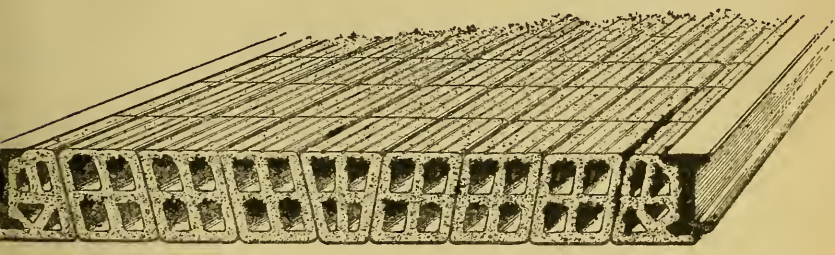


FIG. 1. HOW THE HOLLOW TILES OF A FLOOR ARCH ARE ARRANGED.

pile of lumber at the very brink of this deep well. I knew better than to look down, because I was too apt to get dizzy, but Bill caught hold of a cable and leaned far over the edge. Suddenly the cable moved up, yanking Bill almost off his feet. I caught and steadied him or he might have pitched overboard.

"Look here, Bill," I shouted, "what's the use of taking chances? Suppose that cable had started running down; nothing could have saved you."

"How did I know the cable was alive?"

"That's just the point, because you didn't know, you couldn't afford to be careless."

We climbed on up to the thirty-sixth story and found no flooring except some boards here and there. That ladder did not take us any further, but we saw one off to the right at the outside of the building. Up this ladder Bill climbed and I followed him. The wind was blowing so hard that most of the time I had to hold my hat on. There was nothing between us and eternity but this frail ladder. Below us was the street—500 feet sheer. The ladder was a double one, like the others, but was not secured, and to make matters worse, half way up there was a temporary platform which projected across our path, so that we had to reach far out to one side and worm our way past it. When we reached the thirty-seventh story, I determined I had enough. There was absolutely no flooring on the next story, but the thirty-ninth apparently was provided with a complete plank flooring.

"No, sir, Bill, not on a day like this. I'm going no higher when I have to hold my hat on all the time." Even as I spoke a board fell down from the floor above us within a couple of feet of my head. I looked up and saw a man grinning. I am sure he dropped the board on purpose.

"Well, I'm not going to quit as long as we are so near the top. Here, you watch my hat," he said, placing it on a board and wedging the brim under a steel beam. "I don't need a hat. I'm going all the way to the top."

I watched Bill climb up steadily, story after story, until he disappeared through the hatchway in the top floor.

I was up among the riveters and their pneumatic hammers were pounding away with a noise like the grating of a giant locust, and so loud that it deafened me. I watched a gang at work on my floor. There were four in the gang. One had a forge to which he fed air with a blower turned by a hand crank. In this forge he was heating rivets. Every once in a while he would pick out an incandescent rivet with his tongs and sling it easily but with perfect aim over to a man who sat carelessly on a girder close to where the riveting was done. This man had a bucket in which he caught the rivet; then he picked out the glowing bit of metal with his tongs and placed it in the hole it was to occupy. A third man held a huge sledge hammer with cupped head against the head of the rivet, while the fourth battered down the incandescent end of the rivet with the pneumatic hammer.

Suddenly something struck my straw hat and bounded to the planks at my feet spluttering fire. I was so startled that I jumped a yard; then I realized my hat was on fire. I threw it to the floor and stamped out the blaze amid the guffaws of a gang of riveters overhead.

"Hellow, Babe," they shouted. "Does your mother know you're out? Say skeeters is pretty hot up here, eh? Don't cry. Your big bruvver will be down in a minute. Cheese it! here comes the boss!"

A young man, but powerfully built, ran easily up the lad-

der from the floor below, caught sight of me and stopped short.

"Well, for the land of Jehosophat! Where did you blow in from?"

"I am just taking a look at the building."

"So I see, but how in thunder did you get here?"

"I took the elevator as far up as it would go and climbed the rest of the way."

"But don't you know you can't enter this building without a permit? Where was the watchman? Didn't he stop you?"

"I didn't see any."

"Which way did you come in?"

"Why, I just walked in from the——" I hesitated. "Look here, I don't want to get any one into trouble."

"O, well, you don't need to tell me. That rascal—I know which one it is—he just went around back of the shanty for a pull at the flask. The superintendent threatened to fire him only yesterday, but gave him one more chance. The old fool can't keep sober. Hate to have him thrown out of a job, though. Glad you refused to tell me who let you in. You did refuse to, didn't you? Well then, I don't really know who it was, do I?" appealingly.

"No, no," I reassured him.

"Say, you look as if you had come out of a bandbox. Have the boys been having a little fun with you? Where is your hat? Oh, I see, you stuck it under that girder."

"No, that's Bill's hat."

"Bill? Who's Bill?"

"My chum, he's gone on up to the top."

"The dickens he has! I'll have to go up and see about it. I've got to smuggle you out of here without letting the superintendent know. It is not on your account, you young rascals, but because of that old Jerry. He can't pick up a job anywhere and everywhere like you young chaps, and he won't hold this one very long, either. You get over there a ways where the boys can't meddle with your haberdashery."

I took his advice and watched him run up to the top of the building. In view of my previous experience it seemed advisable to look up and avoid further trouble. The guying I had received rankled in me. I was only cautious, I said to myself, I wasn't really afraid, but it seemed useless to take further risks. I assured myself that if any one's life depended on it I could run around on steel girders as recklessly as any iron-worker. I watched one fellow overhead. He picked up a board and was walking along a beam only a few inches wide. A gust of wind caught the board and swung him around. I marveled that he kept his balance, but he didn't look alarmed; it was all in the day's work.

CHAPTER V.

ALL ABOUT SKYSCRAPERS.

BEFORE long Bill and the "Boss" darkened the hole in the top floor and began to climb down, their coats flapping wildly in the howling gale.

"Say, it was great up there," exclaimed Bill, when he reached my story. "You certainly missed it. That setting gang is a nervy bunch of men. They were setting a girder in place across the top of two columns. Two men were standing on the ends while it dangled from the derrick and swung around in the wind. They couldn't quite get it into position because the wind was blowing so hard, until a third fellow climbed to the top of the column like a monkey, and stuck to it like a fly, holding on with his knees and one hand, while he stretched out over Broadway, caught the hand of the other fellow on the girder, and pulled the end of the girder in place. I see you've lost your hat," continued Bill, as he stooped to get his own.

I was relating my experiences to him when the "Boss" came back from the inspection of some rivetting and hailed us.

"Here Bill and you—what's your name?"

"Jim," I supplied.

"You and Jim come down with me. I have got to keep

you at the rear of the building or the superintendent might see you."

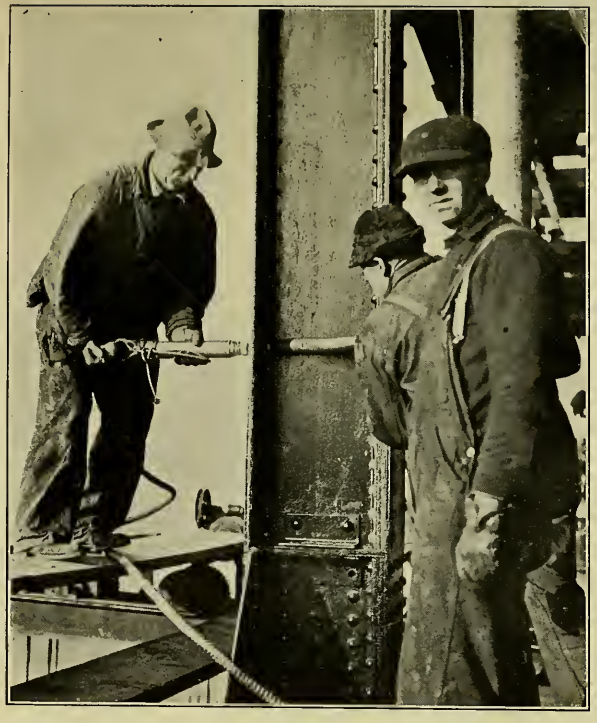
"All right, Mr. Hotchkiss." Bill had already learned his name, also that he was the assistant superintendent on his afternoon tour of inspection. "He makes two trips from top to bottom every day," said Bill, when there was a lull in the racket made by the pneumatic hammers.

At each story Mr. Hotchkiss left us to make ourselves as inconspicuous as possible while he walked around to look at the character and progress of the work. At every opportunity Bill quizzed him and he was always good natured enough to answer our questions explicitly.

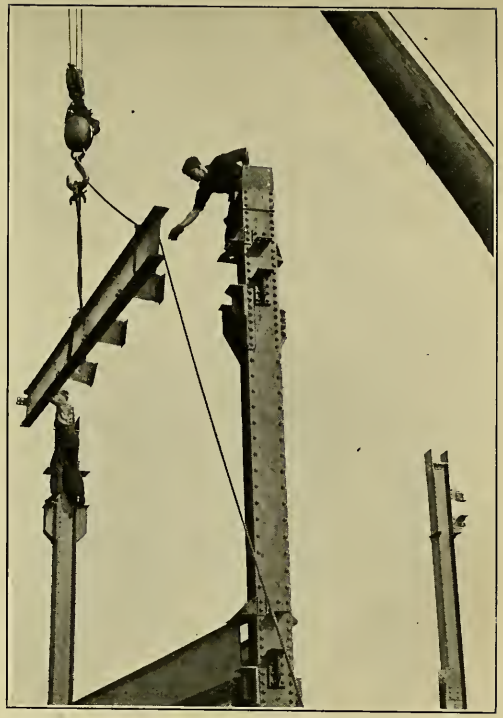
I was astonished to learn that every steel piece in the building was numbered and had a fixed place on the plans. "Why, certainly," said Mr. Hotchkiss, "this whole building is constructed on paper first. Every part is figured out in proportion to the load it has to carry, and then the parts are made at the factory. The holes are drilled for the rivets and everything is prepared so that we can put the pieces together with as little work as possible. First the setting gang assembles the parts, fastening them with a few bolts, just enough to keep them in place, then the fitting gang goes over the work, reams out holes that do not quite match and corrects any little misfits due to the warping of the metal. Finally the riveting gang comes along and replaces the bolts with rivets."

Mr. Hotchkiss hurried off to see the boss of the arch-men, while we prepared more questions to spring on him.

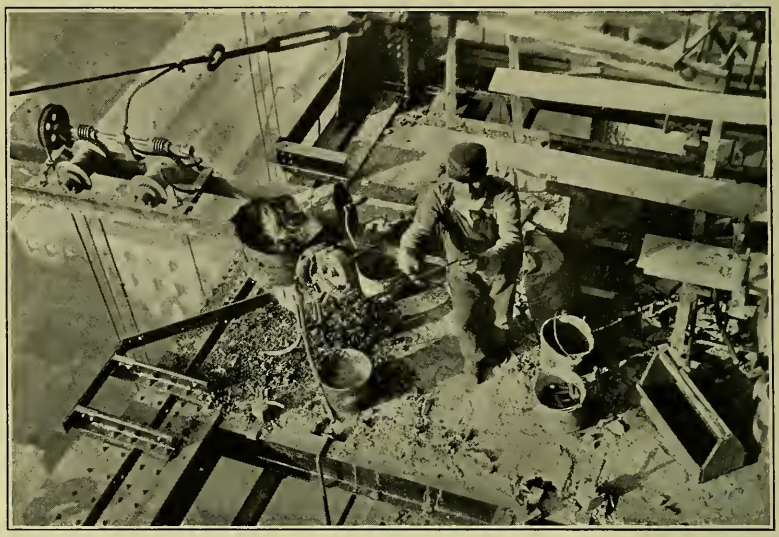
"They've got to hurry up with those floors," said Mr. Hotchkiss when he came back. "We are not allowed to let the steel work get more than three stories ahead of the floors. We are way behind now, and there is liable to be trouble. The archmen can't keep up to the iron-workers. It takes them only about five days to put up two stories of steel work. The columns," he explained, "are always two stories high. The entire steel work for two stories at a time is ordered from the storage yard over at Bayonne, a couple of days before we need it. There a man sorts out the numbers we call for and ships the stuff on a lighter to the Battery, after which it is drawn by horses to the building. Sometimes the load is pretty heavy. The heaviest piece we tried to handle was a girder weighing 61½ tons. It was eight feet high, nearly eight feet wide, and about 25 feet long. We did the hauling one Sunday morning, when the streets were deserted. It took 42 horses to pull that load, with 14 drivers to urge them on. The heavily weighted truck cracked and crushed through manhole covers as if they were nuts. I tell you it was some procession; and then, when we tried to lift the girder, the fun began. It takes some time to balance a load like that, you know, and we had just got everything fixed and the girder a foot or two off the truck, when down she came with a bang that put the truck out of commission for keeps. A 'goose neck' of the derrick had broken, one of the heavy steel pieces about two inches thick at the top of the mast of the derrick that joins it to the two slanting legs."



BATTERING DOWN A RIVET WITH A PNEUMATIC HAMMER.



REACHING OUT INTO SPACE FOR A SWINGING GIRDER.



PICKING OUT AN INCANDESCENT RIVET WITH HIS TONGS.

HAND RIVETING WHERE PNEUMATIC HAMMERS CANNOT BE USED.

"Wasn't the girder smashed?" we queried.

"Oh, no, it wasn't hurt in the least. We took it apart—you know it is built up of plates and channels—and hauled it up in three separate sections."

"Where are the engines that work the derricks?" asked Bill.

"On the same story with the derricks at the start, but the derricks are moved up, story after story, until they are six or eight stories above the engine, before the engine is moved."

"And the signals," I put in, "how do you manage them?"

"At first we had a man stand at the edge of the building, on the floor where the work was going on, and he sent signals to the engineer, by pulling a rope that rang a bell. Now that the building has reached such a height we have the signals sent by electricity from the ground to the man on the floor where the derrick is set. He in turn touches a button that communicates the signal to the engineer."

I thought my adventures were over. We no longer had to crawl down ladders, for we had reached the iron stairways at the rear of the building, but we had one more experience and it was a thriller. To save time Mr. Hotchkiss bade us go down five flights and wait for him, as he had to attend to some work at the front of the building and would find his way down by another stairway. On the third flight down, the stairway was blocked by a pile of building materials, and the only thing for us to do was to walk across an open shaft on a beam not over a foot wide and jump

from there to the landing, about eight feet below. The beam was at the outside of the building and there was a drop of ten stories from it to a narrow scaffold. I was leading and I took in the situation at a glance. Ever since my experience on the thirty-seventh story, the taunts of the rivetting gang had been rankling within me. I was no coward, I kept assuring myself, if necessity arose I was positive that I could walk a fence rail over Niagara Falls. Here was my chance to prove it. I would show Bill, and any one else who happened to be looking, just what I was made of.

All this went through my brain like a flash, and without a moment's hesitation I mounted the beam and walked confidently along it, my eyes on the opposite side. But the wind was blowing so hard that I had to lean out over the side of the building to keep my equilibrium. I hadn't ventured three steps when my eyes took in the awful depth below me. At once a sickening horror seized me. I wavered and grew dizzy. Something seemed to be dragging me, forcing me out over that yawning depth. I reeled, clutching at the air for some support. Just then a sudden lull in the wind made me lunge outward. Everything grew black before me. I felt a twist at my back, a wrench, and then a crash and a succession of bumps.

Bill had run up behind me, seized me by the knees, in a flying tackle, at the same time half-falling and half-jumping for the stair landing. We struck it and rolled down the stairs, fetching up on the floor below. I don't know

what I looked like, but Bill's face was the color of ashes and beads of perspiration stood out on his forehead. We sat there staring foolishly at each other for a full minute.

"Bill, you old chump," I said, "you saved my life."

"Oh, cut it!" Bill replied.

We picked ourselves up painfully, brushed our clothes and went shakily down to the story where we were to meet Mr. Hotchkiss. Fortunately we had a long wait, which gave us plenty of time to compose ourselves.

"Say, Jim," said Bill, "we set out to find out about those big cylinders they were hoisting to the top of the building, and here we have forgotten all about them." When Mr. Hotchkiss came back we asked him all about it.

"That," he said, "is the smokestack. It will run up to the very top of the building."

"It must be very heavy," I ventured.

"Oh, no, not at all. It is made of light stuff. It looks heavy because it is so bulky. Each section is two stories high and is supported by brackets on the floor beams, so that there is no more weight on the bottom section than on the top. The sections are not riveted together, but are connected by slip joints. That gets rid of any trouble from expansion and contraction, you see."

"You must be going to have quite a powerful plant to need such a smokestack."

"It will be quite a plant, 2,400 horsepower. It takes a lot of power to run a building like this. We expect to have from 7,000 to 9,000 tenants. That makes a good-sized

town, eh? And we are going to supply them with 81,000 lamps. Why, there will be enough wire in this building to reach from New York to Philadelphia."

A few stories further down we came across the men who were building the walls. I was astonished to find that what had looked from the street like marble was really terra-cotta coated on one side with a sort of enamel. It seemed like a fraud, but Mr. Hotchkiss explained that this material was not only cheaper, but in every way better, than real stone. It was much lighter and was thoroughly water-proof. No water could soak into it to freeze and chip or flake-off the surface, in winter time. He explained how it was that the walls were not started at the ground floor. Each story carried its own wall, supported on brackets, and so the wall could be begun anywhere. As the first four stories were to be of stone and the work of setting the stone was comparatively slow, there was no necessity of waiting for the stone work to be completed before going on with the terra-cotta. The walls were actually built of brick with a facing of enamelled terra-cotta attached to the brick by means of metal straps or bands. The only reason for using real stone on the lower stories was because the imitation could too easily be detected so near the street. Large blocks of stone were used, and these had to be set in place very carefully. Some were left rough so that they could be carved. As with the steel work, every piece bore a number which designated the particular spot it was to occupy; even the terra-cotta pieces were numbered. It

impressed me greatly to find that every piece of the wall was accounted for, and my respect for the architect went up a hundred-fold. It seemed almost like keeping count of the very hairs on one's head. Mr. Hotchkiss told us that all the ornamental terra-cotta was designed on paper, full size, sheets ten and twelve feet long being required for some of the pieces.

"When the walls are finished I should think the building would rock like everything in such a gale as we are having today."

"Rock? Oh, no, you would never know there was any wind whatever if the windows didn't rattle. Some buildings sway enough to set pictures all askew, but we have made this tower so solid it can withstand a wind of 200 miles per hour, and the record in New York is less than 100. The building code of the city makes us provide for a wind pressure of 30 pounds per square foot over the whole surface."

We had reached the sidewalk by that time without running across the superintendent and Mr. Hotchkiss felt much more free to stop and converse with us.

"Aren't you ever going to reach the height limit of these tall buildings? I should think they would soon be too heavy for their foundations."

"Not at all, not at all," said Mr. Hotchkiss, looking around for an illustration. Then he fumbled in his pockets and pulled out a small bolt. Unscrewing the nut he measured it and found that it was a scant inch square.

"That's less than one square inch, eh?"

We nodded assent. Then he placed the nut on the ground and stood on it. "There, now I am subjecting the ground to a greater strain than is this whole building."

We looked at him incredulously. "Yes, I weigh 210 pounds. Two hundred and ten pounds on one square inch makes how much per square foot? Reckon it up."

Bill had his note book and pencil out in a jiffy and started figuring. "Fifteen tons per square foot," he announced presently.

"That's it. The building regulations of this city do not allow a weight of more than 15 tons per square foot on the foundations. A foolish regulation, in my estimation, based on the idea that concrete would crush under a heavier load than that; but the kind of concrete we have nowadays, thoroughly reinforced with steel, will stand a far greater pressure. You can see for yourselves how ridiculously light the load is when you figure it down to square inches. Why, many a fat woman, who picks her way across a muddy street on her French heels, violates the building code for foundation pressures."

"But I can't believe," I protested, "that a big building like this puts a strain of only 210 pounds on the ground. Do you mean to say that if you cut a sliver out of this wall from top to bottom and only an inch thick by one inch wide it would not weigh more than 210 pounds?"

"Well, not exactly that. If your sliver was cut out of one of the steel columns it would weigh eight or ten times

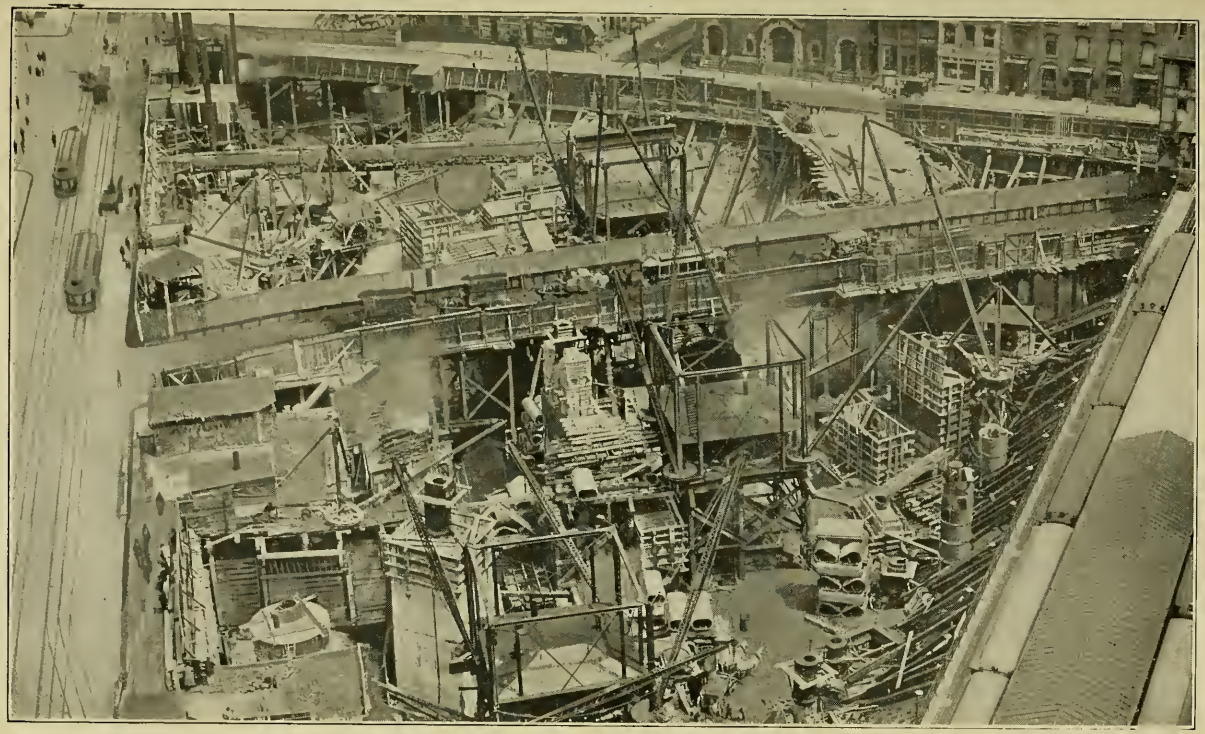
as much as that, and if it were cut out of the elevator shaft it would be as light as air. You must remember that very little of this building is solid all the way up. At the bottom of the columns there is a foot piece that spreads the weight over a large area of concrete. There are 69 concrete piers under this building. It is a regular centipede with concrete legs all over that stand on rock 120 feet below the sidewalk. Some of those legs are 20 feet in diameter. You will find that there are quite a few square inches in the foundation supports of this building. Altogether the finished structure is going to weigh something like a hundred thousand tons, with an allowance of twenty thousand tons more for wind pressure. That isn't very much when you consider the size of the building. If you threw the building into the ocean it would float, provided the doors and windows did not leak. What is more, fully five-sixths of the building would project out of the water. The United States Bureau of Standards is now making some tests to see just how much the steel columns will be compressed by the weight they have to support. They have made two very fine markings, about 20 inches apart, near the base of one of the columns, and every now and then they take measurements to see whether the distance between these marks has been diminished. Their instruments will measure differences of one ten thousandth of an inch. It is probable that when the building is completed the steel columns will actually be compressed about an inch and a half under the weight they have to support.

"Oh, we haven't reached the height limit by any means. Somebody has figured out just how tall a building could be erected on a plot 200 feet square without violating the building code. He estimated that the building would be 150 stories high, reaching 2,000 feet in the air; and it would weigh 516,500 tons. It would cost $60,000,000, and it would have to withstand a wind pressure of 6,000 tons. As a matter of fact, it would take something like 50,000 tons of wind pressure to upset the structure. Of course, a building like this would not stand on concrete legs, but would have a single solid foundation pier 200 feet square, running down to bed rock. If the steel work could be erected directly on the rock, without any concrete between, no doubt permission could be obtained to add a few more stories on top. Up-town they don't have to bother with deep foundations as we do."

"Did you really have to dig down 120 feet for the foundation for this building?" asked Bill.

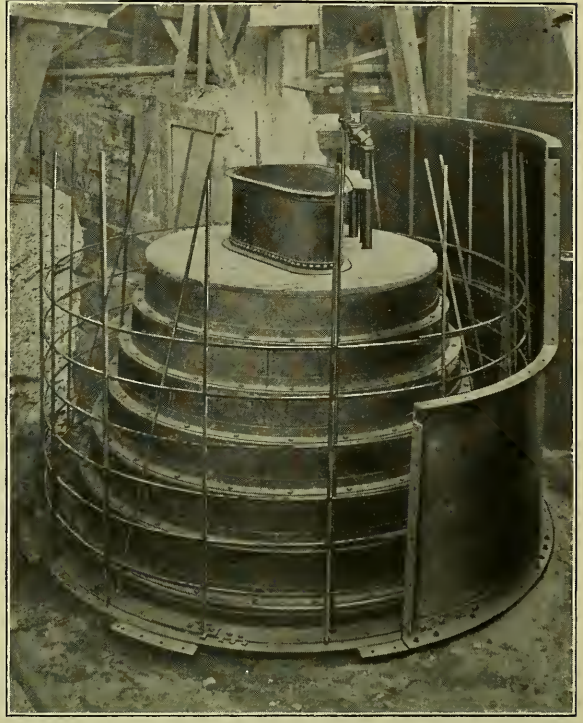
"Why, certainly we had to. You know how it was done, don't you? What! never heard of caisson work? Well, there is a treat in store for you. Five blocks down Broadway they are sinking some caissons now for a 25-story building. You go down there and ask for Jim Squires. He is a personal friend of mine, and he will show you all there is to show. I'll have to be going now. Glad to have met you, boys. So long!"

We shook hands with him, thanked him, and apologized for all the trouble we had put him to.



FOUNDATION WORK OF THE MUNICIPAL BUILDING VIEWED FROM THE BROOKLYN BRIDGE.

CAISSON WEIGHTED WITH IRON BLOCKS TO FORCE IT DOWN. BETWEEN THE PILES OF BLOCKS IS THE AIR-LOCK.



SETTING UP THE FORMS AND REINFORCING BARS FOR CASTING A CONCRETE WORKING CHAMBER.

"Say," he called, as we moved off, "if you have any more questions to ask drop in at the office any time around noon and ask for Dick Hotchkiss."

CHAPTER VI.

A HUNDRED FEET BELOW BROADWAY.

IMMEDIATELY after breakfast on the next day we went down town to see how foundations are sunk to bed rock in lower New York. The place we wished to investigate was enclosed by a high board fence, but projecting far above it was a confusion of derricks, concrete mixing machines, bucket elevators, enormous wooden boxes and curious cylindrical objects from which every once in a while would come the sound of a whistle signal followed by a loud gasp of escaping air. The lid of the cylinder would drop in and a large bucket of dry, white sand would be drawn forth and dumped into a hopper; then the bucket would be swung back into the yawning mouth of the cylinder and an attendant would swing a lever closing the lid. Thereafter there would be a number of toots of the air whistle and we could see the bucket cable pay out or in in accordance with the signal.

It all seemed very mysterious and whetted our curiosity. We sought out Mr. Squires without further delay. He proved to be a very approachable man, the kind that hadn't forgotten that he was a boy once.

"If Dick Hotchkiss sent you here," he said cordially, "you may have anything you wish."

Bill explained that we were anxious to know how foundations are sunk. "Simply a case of dig, dig, dig," said Mr. Squires, "until we get to rock; when we get down to water we keep it out of the excavation with compressed air."

"How do you do that?"

"On the same principle as the diving bell. You know if you plunge a tumbler mouth down into a basin of water, the air trapped in the tumbler will keep the water from filling it completely. If enough air were pumped into the tumbler it would be possible to keep out every drop of water. We do that very thing in building foundation piers. First we make a big diving bell, called a caisson. It is a large box of wood or steel or concrete with the top and bottom open. At the bottom the box has fairly sharp cutting edges; about seven feet up from this cutting edge there is a horizontal partition called the 'deck.' This is made very strong, because it has to carry the weight of the whole concrete column while the digging is going on. 'Sand hogs,' as we call them, get into and out of the working chamber under this deck through a tube, or 'shafting.' They dig away the soil and gravel below, constantly undermining the caisson, so that it gradually sinks into the earth. As the caisson is sunk the concrete pier is built up on its deck and its weight helps to force the cutting edges into the ground. As the work progresses new caisson sections are added on top and the shafting is extended for the sand hogs and excavating material."

"But where does the water come from," I asked.

"The lower end of New York is built over a deep layer of sand and porous soil that is saturated with water from the river. About thirty feet below the curb, in this part of New York, we come to water, then we have to put on the air pressure to keep it out. The first thing we must do is to put an "air-lock" on the shafting, so as to let the men in and out without losing all the pressure. The lock is just a cylinder with a hinged lid or door at the top and bottom. One or other of those lids must be closed all the time to hold the pneumatic pressure in the caisson. The bottom door is closed when the top door is open to let the men in. After they enter the lock-tender lifts the upper door shut and turns a valve to let the compressed air in. All the time the bottom door is kept closed by the air pressure in the shafting below, but as air is let into the lock at length its pressure equals that in the caisson, and there being nothing to hold up the bottom door, it swings open of its own weight, so that the men can go down to the working chamber."

"Say, could we go down into one of the caissons?" asked Bill.

"Oh no, entirely out of the question," said Mr. Squires. Then, as he saw the disappointment in our faces, he explained: "There isn't anything to see down there, and it is pretty dirty work."

"We don't mind the dirt," I interrupted.

"Well, I don't know," said Mr. Squires, hesitating, "you

say Dick Hotchkiss sent you to me. That settles it, then, if you really want to go. Come on to the sand hog house and I'll see if I can rig you out in boots and oil skins. But hold on! When did you have breakfast? Eight o'clock? Didn't have a very substantial meal, did you?" We told him what constituted our usual morning fare. "Not enough," he said, "run over to that restaurant and fill up with all you can eat."

That seemed like an odd preliminary to our work.

"Like feeding the murderers just before they are to be executed," I remarked.

"But," Mr. Squires explained, "you are going down where you will take in three times as much oxygen with every breath. Your in'ards are going to work under forced draught and so you must have plenty of fuel on board. It is one of the rules that the men cannot go under pneumatic pressure except on a full stomach." So we repaired to the nearest restaurant and filled our bunkers with broiled steak and apple pie.

"Now we shall see the doctor," said Mr. Squires.

"The doctor!" we both exclaimed, "why, we are not sick!"

"No, but every one has to undergo a physical examination before entering a caisson."

All this preliminary was most impressive. For the first time it occurred to me that there might really be some danger, but, shucks, what did I care about dangers as long as I could feel good, solid earth beneath me.

The doctor was such a serious looking man that we never for a moment imagined he might play a joke on us. He felt of my pulse, looked at my tongue, listened to my heart, and then thumped and pounded me unmercifully all about my chest and back to see if I were perfectly sound. I tell you I was sore before he got through with me. I ached all over, but found some consolation in the thought that Bill's turn was coming next. After Bill got his, the doctor began, in a clerical tone, to sermonize on the awful hazard we were inviting upon ourselves. He told us that we were to enter a chamber where the air was compressed to over three times the density of the atmosphere. "On every square inch of your body," he said, "there will be a pressure of 35 pounds above the ordinary pressure of the air, and 35 pounds on every inch means 500 on every square foot, or about 50 tons on your whole body. Think of that, young men, 50 tons! Why, that would smash you as flat as a griddle cake if you did not take air of the same pressure inside your body, so that it would press out and counteract the inward compression. The weakest spots are your ear drums. You will have to look out for them. They are liable to burst unless you can get compressed air up your eustachian tubes. The only way to do it is to take a long breath and then, holding your nose and keeping your mouth shut, blow for all you are worth."

I began to suspect that we were providing a lot of fun for these men, but they were both so insistent about it that we had to practice blowing, so that we should know how

to do it when in the air lock. I learned afterwards that that bit of practice was the only really important item in the whole farcical examination. The doctor explained how men who didn't heed instructions were sometimes afflicted with a dreadful malady known as the "caisson disease."

"In its very mildest form," he said, "you are seized with cramps and shooting pains from which you can get no relief. Every bone in your body will ache so that you cannot sleep. In the more serious stages you become paralyzed. The paralysis spreads until it strikes a vital organ and you die. There is one simple test of your condition. Can you whistle? Yes; well, as long as you can whistle you are all right, but if, after you have been in a while, you experience any difficulty it means trouble. Your lips are losing their sensitiveness, a slow paralysis is coming on."

At this Mr. Squires had a terrific coughing spell, but there was not even the flicker of a smile on the doctor's face as he waived us off. Mr. Squires led the way up a ladder to a platform surrounding one of the cylinders we had seen. Just as we got there, there was a sudden blast of air, the trap door at the top opened, and out came a load of sand. We climbed into the lock and the lock-tender closed the upper door. The lock was a large chamber about six feet in diameter, lighted by an electric bulb. At the bottom there was a trap door. Mr. Squires warned us against standing on it. The lock-tender turned a valve and let the compressed air rush into our chamber with a loud hissing noise. The noise was so deafening we couldn't

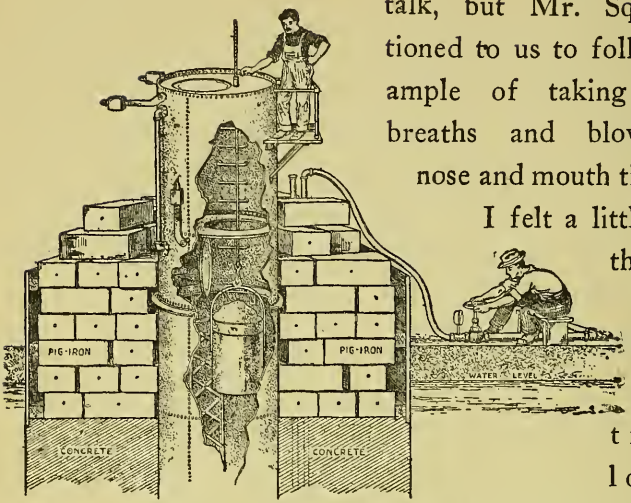


FIG. 2. PASSING A BUCKET THROUGH THE AIRLOCK. BEHIND THE LATTICE IS THE WORKMEN'S LADDER.

talk, but Mr. Squires motioned to us to follow his example of taking in deep breaths and blowing with nose and mouth tightly shut. I felt a little queer as the pressure came on, but was in no distress. I looked at Bill and couldn't help laughing. He was following directions so conscientiously, taking in copious breaths and blowing until his cheeks were distended like balloons.

Suddenly the trap door below us dropped open with a clang that echoed and re-echoed down the yawning well which seemed to run to the very bowels of the earth. The well was pear-shaped, with a lattice partition dividing it into two shaftings, the smaller one

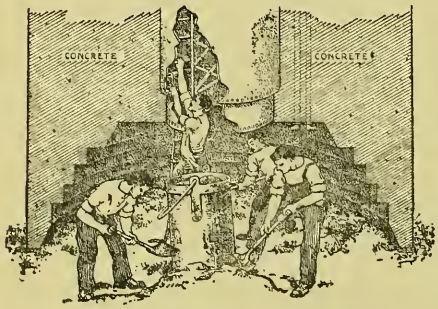


FIG. 3. THE WORKING CHAMBER OF A CONCRETE CAISSON HAS A STEPPED ROOF.

for the workmen and the other for the sand bucket. The trap door opened into a chamber with a narrow ledge and we had to climb down into it and then over to workmen's shafting. Then Mr. Squires pulled a whistle cord, in response to which the lock-tender swung the bottom door shut.

A ladder led down the workmen's shaft, which was lighted with a few electric lamps. We could see the shaft tapering with the perspective until it formed but a tiny hole where it passed into the working chamber, a hundred feet below us. In the murky darkness we could barely make out the forms of men in the chamber, who looked like gnomes in an elfin world. We had been transferred into a real live chapter of the Arabian Nights.

I tried to speak to Bill, but my voice sounded so high and nasal that I could scarcely tell what I was saying. Mr. Squires had already started down the ladder and we scrambled after him. It was a long tedious descent and I wondered how we should ever get up again. Somehow I felt a peculiar exhilaration. It seemed easier to do things in that atmosphere.

When at last we reached the bottom of the shafting we wriggled down a rope ladder to the ground. The working chamber was rectangular, measuring about 10 by 15 feet; five sand hogs were at work. They had dug a wide hole in the sand at the center of the chamber and were extending it toward the sides. Mr. Squires explained how they would dig to the edge of the chamber, undermining the edges of

the caisson, if necessary, so that they would sink into the ground. The deck, a foot or so above our heads, was made of heavy timbers, and supported a concrete pier that extended in a solid mass 80 feet above us. The shaft was getting so deep that the weight of the concrete was no longer enough to force it down, and tons of pig iron were loaded on top to overcome the friction of the earth on all sides of the caisson.

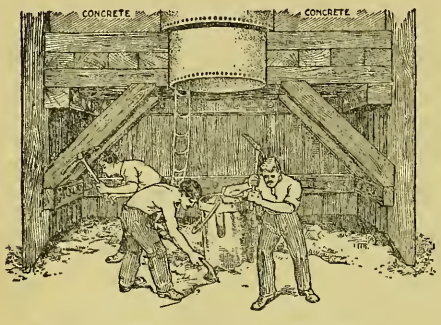


FIG. 4. WORKING CHAMBER OF A WOODEN CASING.

"Now-a-days," said Mr. Squires, "caissons for deep building foundations are nearly always made of steel or concrete. We happen to be using wooden caissons here because the contract for this job was not let until the last moment. The wreckers had already removed the old building that stood on this property and we had to start operations at once. There was no time to build concrete caissons or wait for steel ones from the mill. It doesn't take long to build a timber caisson and lumber is always at hand."

It was damp in the chamber and water dripped from the ceiling, but the sand floor was quite dry. The air forced all the water out of the sand. It was hot in there, too. Mr. Squires explained that compressing the air heated it and if they did not use a special cooling system the

temperature in the working chamber would be simply unbearable.

My! how those men worked. "You see they are taking in such a lot of oxygen at each breath," explained Mr. Squires. "Take them out in the open and they are too lazy to do a thing. 'Once a sand hog, always a sand hog' the saying goes. They are simply unfit for work unless stimulated with oxygen. They can only work two hours at a time in this pressure. It is dangerous for them to be in any longer."

Mr. Squires turned on his heel and started whistling. As if of one mind, Bill and I puckered our mouths for a whistle, but the sound failed to come! In alarm we tried again, and yet again, but without avail. Thoroughly frightened we ran after Mr. Squires and told him that we had symptoms of paralysis; we couldn't whistle.

"Try harder," he urged. "Sometimes if you put forth a little effort the symptoms disappear." We blew until we were red in the face. He looked genuinely concerned and, calling to one of the men, said: "Here, Pat; take these two boys to the doctor at once and tell him they can't whistle."

Pat grinned from ear to ear as we made for the ladder and began climbing like mad. I thought we should never reach the lock. A hundred feet up was three times as much as a hundred feet down. Try running up to the ninth floor of a building and then imagine how much harder it would be to make that same assent up a vertical ladder.

What if the paralysis spread to our arms and legs before we got to the top. We were pretty well fagged before we reached the lock, and stood on the narrow ledge of the chamber, but the rich oxygen we took in with every breath sustained us wonderfully. Pat was not far behind us. He shouted to us to get down out of the way of the trap door, then he gave the signal and presently the door fell open.

We dragged ourselves into the lock and the door closed behind us. Then we waited an interminable time for the compressed air to be let out. The chamber filled with fog as the pressure was reduced and after a time the upper door clanged open and we jumped out into the sunshine.

A shift of sand hogs gathered around the door of the doctor's shack as we were ushered in.

"Docther," said Pat, "these bhoys is afflicted with serious symptims. Their whistlin' orgins is paralyzed."

"Most distressing, most distressing," replied the doctor. "You will have to get them a tin whistle, Pat." The guffaws of laughter that greeted this prescription were disconcerting, to say the least. We were completely taken in. How should we know that it is very difficult to whistle in air as dense as that in a caisson, and that only by considerable practice can one acquire the art of making "lip music" under pressure. However, there was nothing to do but to laugh with the rest and make the best of the joke. The doctor made us stay in his office for a half hour or so, so as to keep us from becoming chilled and made up for the prank he had played upon us by recounting some very curious adventures

he had had. Presently Mr. Squires came in and we had to go over the whole story again.

"It was one on us, all right," said Bill with a forced laugh, "but you sent us out before we had seen half there was to see."

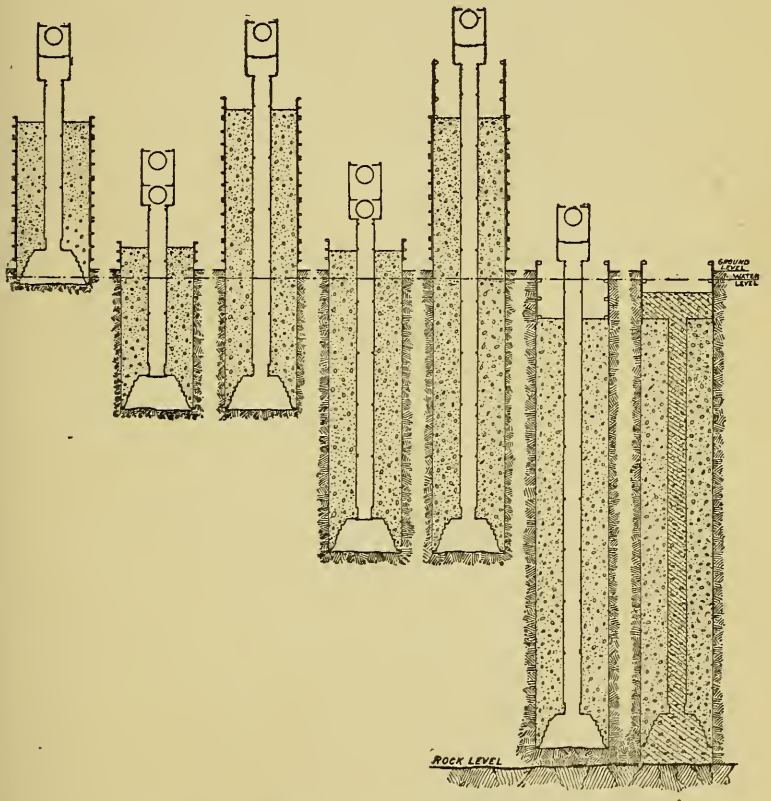


FIG. 5. SUCCESSIVE STEPS IN SINKING A CAISSON.

Starting at the left the caisson is sunk from 1st position to 2nd position. Then the air lock is removed and the caisson is built up as shown in 3rd position, after which it is sunk again to 4th position. Thus the work continues, the caisson being alternately extended and sunk, until rock is reached, when the working chamber and the shaft are completely filled with concrete as indicated in the last view of the series.

"What is that you wish to know?"

"I'd like to know what you do when the caisson is sunk all the way down to rock?"

"We blast out a good footing if the rock it tilted."

"What! You blast rock down in that small chamber!"

"Oh, yes, the sand hogs all get out of the chamber when the charge is set off. We have trap doors at the bottom of the shaft. The men all climb into the shafting and pull up the trap door, then the gang boss sets off the charges with electricity."

Mr. Squires pointed to a scar on his forehead. "You see that? I got that when I was a young lad, before electricity was used for touching off dynamite. I was the gang boss and had set the dynamite in the holes, fixed my fuses and lighted them; then I ran up the ladder to the shafting. One of the fuses must have been extra short; before I could close the door the charge exploded. The detonation was terrific. Rocks were hurled in all directions. One was thrown directly upward; it struck my forehead and tore a big gash in my scalp. Narrow escape, eh?"

"I should say so. But after you have finished blasting what then?"

"Oh, then we just fill in with concrete. The concrete is laid round the cutting edges first. The filling then proceeds toward the center. Then we work up the shafting, filling up the hole behind us until the entire pier is built up solid."

"But do you leave the shell of the caisson in the ground?"

"Certainly. Shaftings are sometimes made collapsible

so that they can be taken out. The one you were in is like that. What next?" asked Mr. Squires.

"I can't think of anything more; can you, Jim?"

"No, not without going in again," I replied.

"You can go down with Danny Roach in one of the narrow cofferdam caissons, if you like," he answered. "We find it necessary to build a solid wall all the way down to rock on two sides of the building, because we expect to have a pretty deep cellar and the adjacent buildings were built on floating foundations. Not many years ago foundations used to be made that way. Piles were driven into the mud and sand as close to one another as possible and then upon them was built a grillage of iron rails. Upon this grillage the columns of the building were supported. That form of foundation is pretty good until some one digs a deep hole near by, then the quicksand oozes into this hole under the weight of the building and the building settles badly, sometimes dangerously. In Chicago most of the buildings are supported on floating foundations. There is a top layer of thick clay underlying the city which provides a fairly good support, but some large Chicago buildings are constantly sinking. For this reason scores of hydraulic jacks are placed under the columns and now and then the building is jacked up to its original level. We have to run a wall all around our foundations here to keep the quicksand out of our subcellar. But run along with Danny Roach. He'll explain the whole thing to you. He knows more about real caisson work than any other man alive."

Danny Roach, a big broad Irishman, who looked in at the doorway just at that opportune moment, seemed only too glad to show us around.

The caisson we entered was only 5 feet wide by 20 feet long. A group of sand hogs were digging away the sand. It seemed peculiarly sticky material. Our feet sank into it as if it were soft mud, and yet apparently it was dry when we picked up a handful.

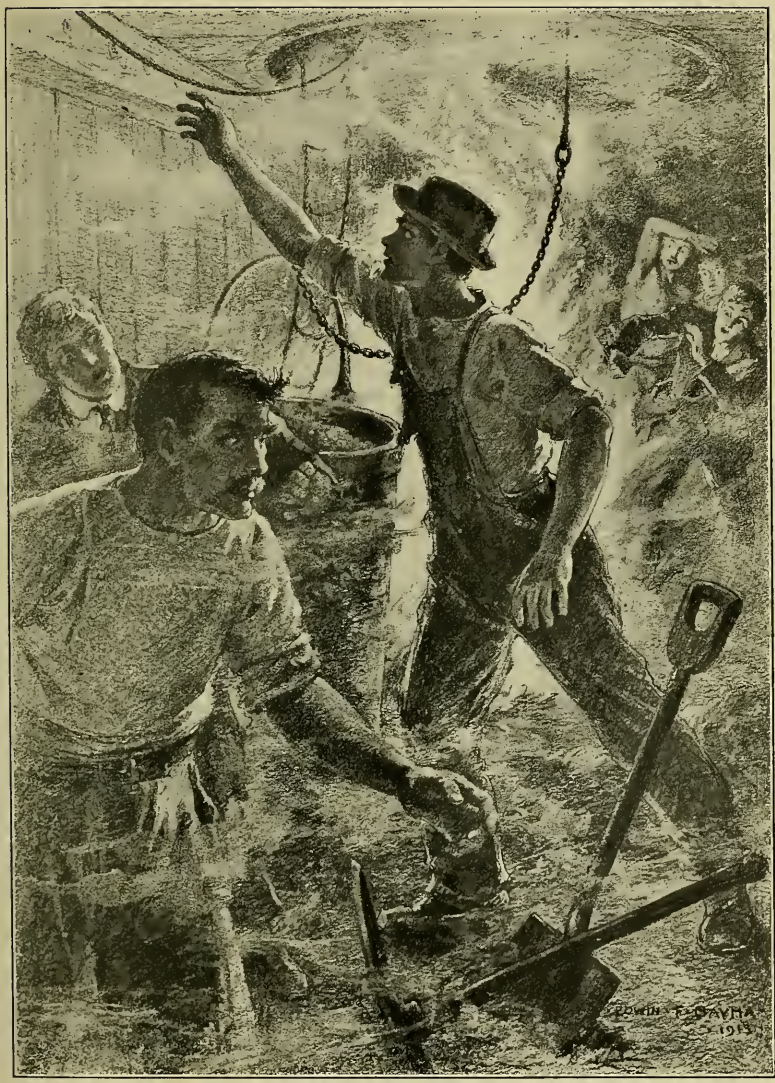
"Tricherous stuff thot," said Danny Roach, "if there wuz no pressure on it it wad be the wurst koind of quicksand.

There was a man in the chamber puttying leaks in the caisson, close to the deck, with clay and oakum. He carried what I thought was a torch, but it proved to be only a common wax candle. The rich oxygen in the caisson drew out the flame to a length of four or five inches. It was wonderful how things burned in that atmosphere.

"Hey! luk out there," called out Danny Roach. "Kape that candle away from thim timbers or yez'll have thim afoire."

"Could you really set that damp wood afire?" asked Bill.

"Sure, if there was a laik the outpourin' air wud suck the flame through the hole and we wud have the worst koind of a foire. Luk out, ye blam' fool!" yelled Danny Roach. The man stumbled, clutched at something to save himself from falling, and, as luck would have it, tore down the electric light wires, broke the circuit and instantly we were in darkness. Even his candle was extinguished, for he fell



FIRE IN THE CAISSON. "HE REACHED FOR THE SIGNAL ROPE."—See page 50.

DOWN TO ROCK IN A CAISSON. ENCOUNTERING TROUBLESOME BOULDERS.

upon it and snuffed out the blaze. The only light was a brilliantly glowing ember in Danny Roach's pipe.

Once, when I was a child, I read of a young chap who crawled into a hollow log after a rabbit and was trapped in there by the inwardly pointing splinters. The horror of that imprisonment which lasted until the next day when the log had to be chopped open, made a deep impression on me. I didn't get over it for weeks, and now that same feeling of horror seized me. It was all I could do to keep from venting my panic in a yell. I don't know about Bill, but I venture he was thinking about the blessed sunshine just then. Presently some one scratched a match; it blazed up brilliantly. A candle was lighted and the match was tossed carelessly aside. Almost immediately there was a flare of light like the flash of gunpowder.

"The oakum!" cried Danny Roach.

There was a big pile of it in the center of the working chamber. It burned fiercely and the heat was intense. We dropped flat upon the sticky sand to keep the flaming stuff from blistering our faces. It was evident that the deck would be ablaze in another instant if something were not done to quench the fire, and if the deck gave away might not the mass of concrete above crush through and mash us as if we were so many flies? But the chances were we would be burned to death before that happened. All this went through my mind like a flash.

In the meantime, Danny Roach had taken in the situation. There was a bucket nearly filled with sand, standing

beside the burning oakum and almost enveloped in the flames. He reached for the signal rope, gave a signal, in response to which the bucket was lifted three feet off the ground, then rushing through the flames he kicked the trip of the bucket. A ton of sand poured out over the blazing oakum and smothered the fire. Danny Roach's clothes were afire and he rolled around on the ground trying to quench the flames. It was with difficulty that we extinguished the blaze, and poor Danny was very painfully burned. He was placed as tenderly a possible in the sand bucket and with the gang boss attending him was hauled up to the surface.

The rest of us climbed up the shafting, which was filled so full of smoke that we could scarcely breathe. We came so near smothering in the lock that we signalled to the lock-tender to let the air out as fast as he could. I tell you what we were glad to get out of that stifling atmosphere.

Poor Danny Roach had done his duty so quickly that I scarcely realized what a hero he was. The doctor was doing his best to relieve the man's suffering until the ambulance arrived. It seemed as if hours had elapsed before it finally did come and we saw our hero carried out to it on a stretcher. A big crowd had collected by this time and the sidewalk was blocked with people. As we stood gazing a young man stepped up and asked us if we knew anything about the accident.

"Why, we were down there in the caisson and saw it all."

"Say, you're just the boys I want to see," he said. "Come

this way. I am Mr. Thomas Graham Watson, journalist of the *Evening Sphere.*"

He led the way to a saloon, but observing our hesitancy, took us across the street to a quick lunch restaurant where we told him our story between bites and gulps; for we were very hungry. He was a master quizzer and before he was through with us he had drawn from us a complete account of our experiences under ground and all about the thousand dollars Uncle Ed had put up for our summer's outing.

"Gee! what luck," he exclaimed. "I can put you on to a lot of engineering stunts. Where do you live?" We gave him our address. "Say, I shall be around to see you to-night. I must hustle off with my story for the next edition."

CHAPTER VII.

THE "BENDS."

"I have a queer pain in my back, Jim. It has been growing steadily worse for the past half hour."

I had noticed Bill twitching nervously for some time.

"Have you it, too?" I asked. "I have felt some twinges in my shoulders and I imagine it's the caisson disease."

"But, it's an hour and a half since we came out of the caisson," said Bill.

"They say it takes anywhere from half an hour to two hours for the 'bends' to come on," I answered, "and as near as I can make out this must be it. You'd better hurry back to the doctor's at once."

"Not on your life. Not unless I'm sure we have it. I won't go there to be laughed at again. If it doesn't get any worse than this I can stand it."

"I ache as if I'd been pounded."

"Same here, my whole body aches like a stiff neck, and I have shooting pains in every joint."

"Oh, let's stop talking about it. I believe it makes the ache worse."

We tried to divert ourselves for the next hour, but our discomfort was not so easily set aside. I never experienced anything so persistent. No matter how I twisted or turned,

the ache was still there. It seemed as if something were gnawing at my shoulder blades, and nothing would make it stop. Apparently, Bill had a more serious case. He was soon doubled up with a crampy pain, and his right leg was drawn up so that he could not walk. He was fairly writhing in agony before we finally decided to go to the doctor. Then he was in such a state that we had to take a taxicab.

"What's this, what's this," exclaimed the doctor, as I dragged Bill into his office, limping and clinging to me for support.

"If this isn't the caisson disease," moaned Bill, "it's something worse."

"My gracious," said the doctor, "you should have been here an hour ago."

"Are we too late?" we cried in alarm. "Is it past cure?"

"Don't worry about it. It is only the 'bends.' It will wear off in a week or two."

"A week or two! And must we suffer like this for two weeks steady? Is there no relief?"

"I can stop the pains at once," he answered, "but I won't guarantee a permanent cure. Get into this lock."

He lead the way to a "hospital lock." The doctor dragged Bill in and laid him on a low couch at one side of the tank, while I crawled in and dropped down on the couch at the opposite side.

"I shall have to stay in with you myself," he said, "the nurse is out just now."

The door was slammed shut and presently I heard the hiss of inrushing air. As the pressure increased, the pains in my bones started to subside. Bill, too, stopped writhing and soon grew quite chipper.

"Bully for you, doctor," he cried, "you have cured us, all right. You can let us off now."

"Hold on, young man. You will have to stay here an hour or two and then it will take at least an hour more to let the air out, because the pressure is up to thirty-seven pounds. You had this attack because the men let you out of the air lock too fast. I can't stay in here with you any longer. If you want to communicate with me, use this telephone."

Now that the pains no longer distracted me, my eyes began to take in our surroundings. We were in a big steel tank. It must have been at least six feet in diameter and from twelve to fifteen feet long. It was divided into two chambers by a central diaphragm or partition with a door in it. We were in the innermost chamber, and the doctor now stepped through the doorway, slamming the door behind him. He didn't lock the door or even latch it, for I could see that it was very slightly ajar. At each end of the tank there was a little round glass-covered port-hole and there was also one in the diaphragm. I arose from the couch and looked through the port-hole to see what the doctor was doing. He went over to the far end of the chamber and turned a hand wheel. The air began to escape with a hiss and the door in the diaphragm closed

tightly, pressed by the denser air in our chamber. The doctor must have spent ten or fifteen minutes in the chamber. Then, as the air stopped hissing, he pulled open the outer door and stepped out of the lock.

We felt perfectly normal now, and there seemed to be no reason why we should stay in that dungeon so long. We spent a very long half hour talking over our experiences. Then we began to grow fidgety. I had to listen to my watch to be sure that it was running. Before the hour was up, we were fussing and fuming over our imprisonment. Finally, I picked up the telephone and called up the doctor, but received no answer. After persistently ringing for about five minutes, some one said "Hello."

"Who are you, the doctor?" I called.

"No, this is John Gray, the nurse."

"Where is the doctor?"

"Gone to supper. He left word not to let you out until he returned."

"When is he coming back?"

"In about half an hour, I guess. He just left five minutes ago."

"Bill, that's another of his jokes, I suppose," I cried, angrily. "I say, Mr. Gray, won't you let us out?"

"Can't do it. Doctor's orders, you know."

"But he is only playing a joke on us. Won't you let us out," I pleaded.

But the man at the other end of the wire rung off, and our repeated calls failed to reach him.

"Now, we're in a pickle," exclaimed Bill, "I suppose there is nothing for us to do but wait. I wish we could get out, though, somehow. We could turn the laugh on him. What did the doctor do when he went out? Did you see?"

"He went into the next compartment and turned that valve over there."

Bill went to the partition and tried the door.

"Oh, you can't budge that," I said.

"Did he lock it?"

"No, it's just the air pressure. He let the pressure out of the other compartment. But, say, there's a valve in here."

"Yes," answered Bill, "and here's another one."

"I suppose one is to let the air out and the other to let it in, but how are we to know which is which?" I queried. "We may let in more pressure than we can stand."

"Well, I'm going to try this one anyhow." Bill gave one of the valves a cautious turn.

"Hold on there, shut it off quick," I cried. "It must be the wrong one because it isn't hissing. The one the doctor worked hissed as soon as he turned it."

"Here goes the other one, then." But there was no hissing that time either.

"Now, that's funny, isn't it? I don't believe either one of them is working," said Bill, "and I don't see why the air shouldn't hiss just as much coming in as going out."

"I bet the doctor disconnected those valves on purpose."

"Our only hope of escape, then, is to call for help."

Bill peered out of the port hole, but no one was in sight. Then he began kicking on the steel walls with his heels. Presently our chamber was darkened by a face at the port hole. It was Pat, and when he saw us he laughed uproariously. We shouted to him to let us out, but he only laughed the louder and called some other sand hogs who peered in at us and evidently made all manner of jokes at our expense, although we could not hear them.

We were getting into a frenzy of excitement and anger when the doctor returned from supper and called us up on the telephone.

"Hello, boys. How are you? Ready to come out, now?"

"Look here, doctor." Bill was fairly boiling over with rage. "This has gone about far enough. It isn't fair to treat us like this. Let us out at once, will you?"

"Don't get so excited," said the doctor calmly, "the pressure has been running out for the last five minutes. This is no joke. I told you, when you went in, that the longer you stayed in the better. Now, just keep quiet. It will take an hour to let all the pressure out. I'm not joking this time."

"An hour?"

"Yes."

"Not a whole hour?"

"Well, fifty-five minutes, if you wish. Now, do calm yourselves. It won't do you any good to worry. I'll come in and visit you if you promise to be patient."

The next minute the doctor stepped into the adjoining

compartment, and then we heard the hiss of air. Before very long the door in the diaphragm swung open, and we pushed through the doorway into the outer compartment. The doctor entertained us by telling us all about the caisson disease and just what caused it. He explained how the oxygen in the compressed air was good for the blood, but the nitrogen forced into the blood would collect there in bubbles. He told us how he had performed an autopsy on a man who had died of the caisson disease, and found his blood frothy with nitrogen bubbles. With the doctor to entertain us the time passed very quickly. The pressure in the lock was being reduced so gradually that we could not detect it. Almost before we knew it, the hour had passed, and the doctor opened the door and let us out.

"My, I'm as hungry as a bear," exclaimed Bill, "it's after seven o'clock. Come on, Jim, let's find a restaurant, quick."

"You may have another attack," called the doctor after us. "If so, don't fail to come back the instant you feel the slightest twinge of the bends."

In the evening Mr. Watson dropped in with a copy of the *Evening Sphere,* and proudly showed us a three-column header on the fire in the caisson. A vivid picture he made of it, with Danny Roach featured as a lowly sand hog, rough, uncultured, whom no one would suspect of heroism; with no thought for his own safety, he had rushed into the fire, etc., etc. Some of his statements were ridiculously incorrect. Yet the story was well told and full of exciting

interest. Worst of all he had dragged us into it. We were two youthful students of engineering, who chanced to be in the caisson when the accident had occurred. We had helped to calm the excited sandhogs, and it was really our presence of mind that had saved all from destruction, for it was upon our suggestion that Danny Roach had acted. Then followed our own "modest" story of the accident.

"What does this mean," I questioned him. "We didn't tell any such story."

"That's all right, boys," replied Mr. Watson. "That's all right. You will thank me for that story yet. Why, it will give you publicity and just the prominence you need to introduce you to engineering enterprises that would otherwise be barred to you. I am going to take you up to the office to meet the City Editor and the 'Old Man' to-morrow morning. I tell you your name is made already. You'll be famous. The whole city will be talking about you."

"We are not here looking for fame," put in Bill.

"I understand, I understand," replied Mr. Watson, "but surely you don't mind having a little publicity if it is going to help you in your studies. Now listen. You got into the Manhattan Syndicate Building on a mere chance, and you got into the caisson just because you happened to be passed along to a friend, but such luck can't go on forever. You'll have to get permits from headquarters and you'll have to meet prominent engineers, and you won't even get past the office boy unless you make a name for yourselves. Now that is where the *Sphere* is going to help you. Lucky for you

times are rather quiet now, and we can well afford to feature you. You might even get a commission from the *Sphere* to go as reporters in places to which you could not gain access otherwise. I tell you," continued Mr. Watson, looking very important, indeed, "the power of the press is well nigh unlimited."

It struck me that maybe I could make something by writing our experiences for the *Sphere,* which would go towards paying my expenses. It would make me feel much more independent and under less obligation to Bill if I could at least pay part of my board.

"Would we get paid for any stories we supplied," I queried.

"Oh, you mercenary creature," laughed Mr. Watson, "like all the rest, your quest is not pure science, but pure gold. Oh, I understand, I understand," he interrupted, as we both protested. "The 'Old Man' will pay you for anything you turn in. He is generous enough to outsiders, but blame stingy with us. If I don't get a raise for my work to-day, I'm going over to the *Evening Star.*"

"But Danny Roach," I said, breaking off abruptly, "what will he think of us after he reads that story in the paper?"

"You'll have to make it right with him. Blame it all on me. I don't care. You'll find him in the Hudson Hospital, doing nicely. I was there to see him this afternoon. He'll be mighty glad to have you call. Now tell me all about the bends, if I am to be your press agent."

"Bill can tell you more about that than I can."

"If you are going to say anything more about us," said Bill, "for Heaven's sake let us read your copy and see that you have things straight."

When he had pumped us dry on the subject of the caisson disease, Mr. Watson took his leave, after exacting a promise from us to meet him on the following morning at the office of the *Sphere*.

"Oh, by the way," said Mr. Watson as he was leaving, "what's the next engineering stunt on your program?"

"We haven't any program," said Bill.

"As long as you have been initiated into caisson work, you might just as well go down under pressure in one of the tunnels they are putting under the river."

"Oh, yes, we intended to take that in, too," I said, "but I for one am not hankering after any more caisson pains."

That night was the longest in my whole experience. The pains in my shoulders, which had almost disappeared during the early evening, came back again and although they were not quite so severe as they had been in the afternoon, they were very distressing. Nothing would ease them. I tossed about, longing for morning to come. Sleep was absolutely out of the question. The racket of the city was maddening. The banging of trolleys, the roar of elevated trains and the clatter of horses' hoofs on the pavement merely lent variety to the incessant hum of city noises. I was even exasperated at Bill for falling asleep. A troubled sleep he was having, but at least he was oblivious to the agony of the bends. A clock in a neighboring church steeple slowly tolled the

hour of midnight. I tried to busy my mind so as to lose sight of my ailments. I counted the seconds until the clock should strike the next hour. Fifty-seven, fifty-eight, fifty-nine, sixty—thank goodness, one minute less before dawn. Again and again I counted sixty; twenty-eight times, twenty-nine times, thirty times. Why didn't the clock strike half past. I must have been counting too fast. I started in again; ten, fifteen, twenty times. What was the matter with the old clock, anyway? May be it did strike when that last train went by. Certainly, that must have been it. I got up and lit a match. Hang it all, the clock hands pointed to only twenty-seven minutes past twelve. I flung myself back on the bed and waited hours for those three minutes to pass. So I went through most of the night, listening for the strokes of that lazy old church clock. Now and then I would doze, only to be awakened by a kick from my restless comrade.

CHAPTER VIII.

REPORTERS FOR THE SPHERE.

When the first feeble ray of sunshine found its way through our window and apprised me of the beginning of a new day, I dragged Bill out of bed, although he protested vigorously.

"Come, you've got to get up. I can't stand this any longer. I am going down to the hospital lock."

"But it isn't five o'clock yet."

"Can't help it. I will have to find some one. These pains are too much for me. Don't you feel anything?"

"Oh, nothing very much."

When we finally reached the hospital lock the doctor was not anywhere around, but a professional nurse put us through the treatment. Bill did not really need it, but he went in to keep me company. It was eight o'clock when we emerged from the compressed air cure, so we hung around for awhile before visiting the office of the *Evening Sphere*. The *Sphere* building stood in the heart of the former newspaper district and because of its conservative management and labor troubles of former years, squatted, a diminutive four-story brick landmark, among its towering associates.

Entering the front door of the general offices Bill lead the way and asked for the *Evening Sphere* City Room.

"Upstairs," a clerical person behind a dilapidated counter tersely directed us.

A steep flight of narrow stairs disappeared into the ceiling on our left and we mounted them. The next floor, which was necessarily "upstairs" to us according to our clerical director's instruction, turned out to be a combination of several departments of the Sphere Publishing Company, the news bureau occupying most of the space and chattering with the staccato snapping of many telegraph instruments.

"This is it," Bill decided uncertainly and turned the knob of a much scarred door.

It wasn't. We found ourselves in a big room filled with long narrow tables cluttered with a variety of typewriters and telegraph instruments and men who were pounding away at the machines as if their very lives depended on it.

"Well?" a cadaverous individual asked our business.

"We are looking for Mr. Thomas Graham Watson," I explained.

"Not here," he snapped, and started to turn away.

"Yes he is," Bill stopped him pugnaciously. "He's on the staff."

"Morning or evening?"

"Evening."

"Upstairs," was the satisfaction we got as he walked off bawling for "Wichita Kansas flimsy."

We left the room and climbed another set of steep and narrow steps to the floor above. A clouded glass door with

the words "The Sphere" printed rather poorly upon it, made us decided that we had at last reached our destination and we walked in. The very large room we entered was filled with old and time worn desks and there wasn't a man in the place. We looked blankly at each other.

"I wonder—"

What Bill wondered he did not have an opportunity to say, as a small boy came charging around the end of a paper filled table and ran full tilt into us. He was apologizing as he started away from us when Bill caught hold of him.

"Where's the *Evening Sphere* City Room?" he demanded not too gently.

"One flight up."

And following the boy's pointed finger we saw a metal door with *"Evening Sphere"* printed upon it. Bill, with a good deal of impatience, yanked it open and lead the way up a circular iron stairway which turned two or three times before we reached the next floor.

There everything seemed confusion. Half-dressed grease-smeared men flashed by, pushing make-up tables on wheels, and the crash of typesetting machines almost drove our thoughts from our minds. An iron wire lattice work partition offered us the haven of safety from the clanking rush of form tables and the stifling heat of matrix presses, and we hurried across to the inclosure.

Thirty or forty desks crowded as close together as they could be to allow for the admission of chairs between them, filled the floor space, and sitting at intervals in front of them

were the men who helped to make the *Sphere* the leading evening paper that it was. In reality they were not more than boys, although we saw an occasional gray head at one or two of the more prominent desks. Pipes and tobacco were in evidence and cigarettes and cigars added to the blue haze of the pressroom which permeated the atmosphere of the place.

"What can I do for you, gentlemen?" asked a bald old man sitting at a rolltop desk near the gap in the lattice work.

"We were to meet Mr. Thomas Graham Watson here," I answered.

"Boy," the elderly person yelled loudly, and followed it with a shrill whistle which brought half a dozen variously daubed and dressed youngsters tumbling from different crevasses in the room.

"Here you!" he shouted. "Tell Mr. Watson that there are two gentlemen to see him."

The boy threaded his way between the desks in a series of spasmodic twists and turns and in a moment Watson confronted us.

"Just a minute, fellows," he apologized. "I'm writing a three-alarm fire for the first edition and will see you soon. Sit down."

We would have liked to, but there wasn't a chair in sight. So we stood and watched the office force.

There was something tense in the feeling of the place. The men who crouched over their typewriters were completely absorbed in their tasks, while to add a touch of in-

congruity to the scene two well-dressed young fellows were tossing a wad of paper back and forth, and a third stood between them trying to hit it with a ruler as it passed him. Bill and I were becoming interested in the third man's efforts when the group were galvanized into action.

"Smith," barked a gray-haired man who sat inside a hollowed out square table, "Bert, Crawley."

The impromptu ball game turned into a quick rush for the man who had called, each of the three participants picking up a hat and a coat on his way to the desk.

The gray-haired man said something, and the three left the office at a brisk pace just as Watson came up.

"Let her go," bellowed a stentorian voice and immediately the writers at their machines straightened up and the tensity of a moment before was gone.

"Form's up," explained our journalistic friend. "Now I'll introduce you to the bunch while we wait for 'Willy'.

"The bunch" was a splendid set of young men who did their best to interest us while we waited for 'Willy.' Their intuition was amazing and before Bill and I realized it they had all of the information about our vacation plans and our hoping to write for the *Sphere* out of us, although just how it was effected neither of us could have said.

"Willy's late to-day," some one suggested, and in answer to our question Watson laughingly explained. "He's our City Editor, William Waldron Wallace is his full name, but just among ourselves we use the diminutive, as a term of endearment. Some facetious young chaps, playing upon

his initials, call him 'Triple-Double-You'. But life is too short for a name like that."

Mr. Wallace, who entered just then, was an undersized, weazened little man, who chewed nervously at a half-burned cigar. He walked quickly into his office with a curt "Mornin' " to us, and must have plunged instantly into his work, for within two minutes he had three or four messenger boys skurrying back and forth. Three reporters were called in and sent off on various commissions, before Mr. Watson had a chance to usher us in. Our interview was very hasty and not very satisfactory, I thought. I was quite awed and noticed that even Mr. Watson was exceedingly respectful. The City Editor looked pleasant enough, but he had no time to waste. After learning who we were, he said he was glad to know us and hoped we would find our summer full of interesting adventure. Then he turned abruptly to his work, jabbed a stub pen into a pot of ink and began writing furiously. We withdrew hastily.

"That is the first step in the red-tape proceedings we have to go through. I want you to meet the 'old man,' but etiquette demands that you be introduced first to 'Willy,' the City Editor, then to 'Charlie,' the Assistant Managing Editor, before we dare see the Managing Editor himself.

The Assistant Managing Editor was a large, pompous man, inflated with his own importance, and so anxious to impress us that I welcomed the end of that interview and sincerely dreaded the one yet to come with the "old man." The Managing Editor, however, was of a very different

type. He was so approachable and so sympathetic that he put us at our ease at once. He commended us highly on the way we were spending our vacation, and bade Mr. Watson keep track of us and help us in any way he could. He also told him to write up our experiences for the *Sphere.*

"Why couldn't we write our own experiences?" I asked.

"Why, maybe you could," he said, looking rather surprised. "Try your hand at it, anyway, and we shall allow you our usual rate of $8 per column. Suppose you sit down now and write a thousand words on your experiences in the Manhattan Syndicate Building. You have an hour before the forms close for the next edition."

"Only an hour!" I exclaimed. "Why, I couldn't possibly do it in that time."

"Well, send it in to-morrow morning, then, and we'll see how you make out."

Early the next morning we hurried down to the office of the Sphere, but, yielding to a spell of diffidence, we handed in our article over the counter, instead of taking it up ourselves to the Managing Editor. Then we hung around City Hall Park, went down to the Aquarium and wandered about the downtown streets, impatient for the morning to hurry by, so that we could see the first edition of the *Evening Sphere.*

"Let's go down to the hospital, to see Danny Roach," said Bill. "We ought to take him something, though. What do you suppose we can give a man like that?"

"Hanged if I know."

"If we took him a bunch of flowers, do you think he'd like them?"

"I don't imagine he'd care much for flowers, but it won't do any harm to take them along. He can give them to the nurse if he doesn't like them."

"We might take him something good to eat," said Bill.

"Then we'd get into trouble with the doctors."

"Suppose we ask Mr. Squires what he'd like?"

We stopped in to see Mr. Squires on our way over to the hospital.

He was leaning back in his chair reading a paper. Yes, it was *Evening Sphere,* "Home Edition."

"Beg your pardon, Mr. Squires," Bill fairly snatched at the paper. "Is that to-day's *Evening Sphere?* May I look at it a moment?"

"Well, I never!" ejaculated the astonished Mr. Squires. "Is that the way you treat your friends?"

I had to apologize for Bill's rudeness and explain that we had written an article for that issue of the paper, and were anxious to see it in print.

"It isn't in!" cried Bill, who had been running rapidly through the paper in the meantime.

A wave of disappointment overwhelmed me. "Are you sure?" I gasped.

"Look for yourself."

I went carefully over every column, but our article was not there. What was the use of life. A whole day's work for naught. Hang the old Sphere anyway.

"You mustn't jump at conclusions," Mr. Squires tried to assure us. "Very likely it will come out to-morrow."

"But the Managing Editor, himself, told us to write it and get it in in time for the first edition."

"Well, why don't you go up and see about it then?"

"No, I am not going to have him tell me to my face that the story was not good enough. What we came around to see you about was to suggest something that we could take to Danny Roach. We want to go around and see him in the hospital. Bill is going to take him a bunch of flowers, but I can't for the life of me, think what to give him."

"That's a poser, now," said Mr. Squires, scratching his head. "I have it. Take him a plug of tobacco."

"A plug of tobacco!"

"Yes, that's just the thing! Poor old Danny must be about dead for a 'chaw' by this time."

Mr. Squires was so enthused with the idea that he went across the street with us and picked out a plug of Danny's favorite brand. Then we went to a Greek florist and bought a nice bunch of roses. Thus equipped, Bill and I headed for the hospital.

Poor Danny was almost overcome by his emotions when he saw us. He was so bandaged up that we didn't know him and had to have him pointed out to us. "Ach, me b'ys," he exclaimed, when he found we were really come to see him and not someone else in the ward. "Ye're the foinest bit av medicine Oi've had yit." He reached out a heavily bandaged hand and gave us each a hearty grip. "Niver a

soul has come near me these two blissed days, excipt that raiporter feller. They lit him in, whin he s'id he was a personal fri'nd av moine, but whin he read me pwhat he'd put in the paiper, Oi caaled for hilp, and had him ejicted, the blackguard. He thought Oi'd be tickled because he made a haro out iv me, but Oi saw through his thricks. He was jist thrying to make as long a shtory out of it as he cud, fur the money that was in it."

"Yes," I said, "he put in a lot about us, too, that was all wrong, and what's more, he signed our names to it."

"Oi'd have him up for forgery," exclaimed Danny indignantly.

"H's not a bad sort of fellow, though," put in Bill. "He introduced us to the Editors of the *Sphere,* and the Managing Editor asked us to write something for them now and then. Jim wrote a fine article yesterday on the Manhattan Syndicate Building, and there were no lies in that, I assure you. We'll send you a copy as soon as it is out."

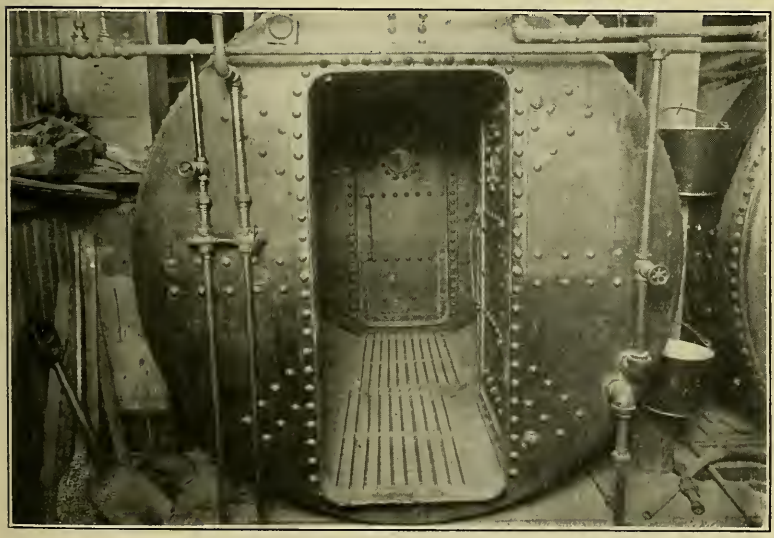
"If it ever does come out," I interjected. "They promised to put it in this afternoon's paper, but it isn't in yet. I guess it wasn't written well enough."

"If yez can't write a bitter article than that Watson feller, yez can't write at all. Oi cud do as well meself."

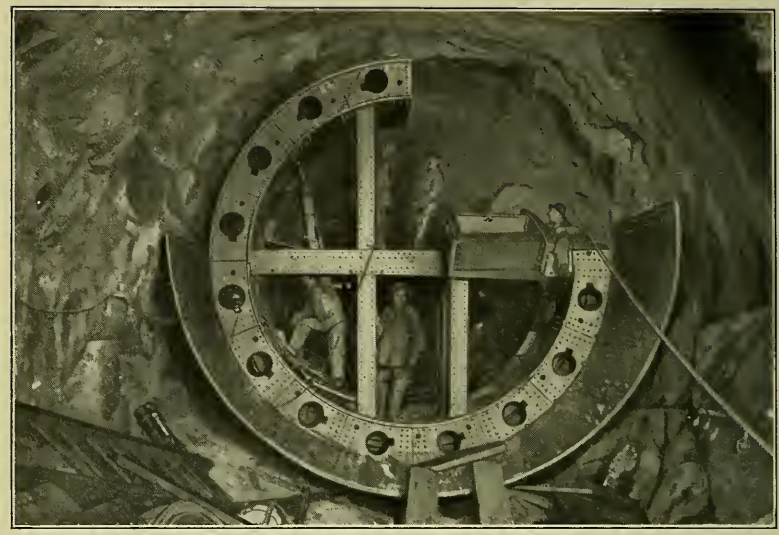
Danny Roach took a great interest in our first journalistic effort, and we had to tell him all about it.

"That foire was nothing worth writin' about," said Danny. "Some day, whin something railly happens, Oi'll send for yez to write it up for the paipers."

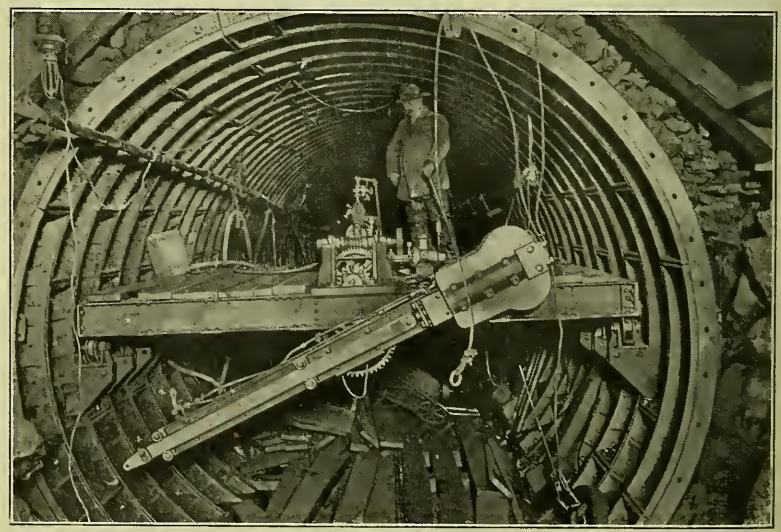
CONCRETE BULKHEAD WITH THREE AIR-LOCKS.



LOOKING INTO A TUNNEL AIR-LOCK.



SETTING UP A SHIELD JUST BEFORE BREAKING OUT OF THE ROCK.



THE ERECTOR CRANE WITH WHICH THE RING PLATES ARE SET IN PLACE.

All this time Bill was awkwardly handling the bunch of roses, not knowing just how Danny would take them. As a matter of fact, I don't think Danny really cared for them. It seemed entirely out of place for a big, gruff sand-hog to be lying on a clean white cot and have roses brought to him. But his warm Irish heart appreciated the thought that had prompted us to bring the flowers. It was not until we were leaving that I handed him the plug of tobacco. Danny was so astonished that he was struck speechless for the moment and that is saying a good deal for him. But as we moved off, he took a savage bite at the plug, which restored his power of speech, instanter, and he broke forth into such a string of blessings as I have never heard before. All the saints were called upon to protect us, at least, I think he must have gone through the whole canon of saints, because he named a full dozen, and was still going strong when we closed the door behind us.

Our feeling of resentment at the Managing Editor of the *Evening Sphere* underwent a revolutionary change the next day when we found our story in the first edition of the paper. Several days later, when a check arrived, made out to my order, I was the proudest boy on earth. I felt that I was really contributing a share, small though it was, toward the expenses of the summer's outing. So I planned to write all I could for the *Sphere.*

CHAPTER IX.

SAND HOGS.

ONE would suppose that after our experience in the caisson we would not care to venture again into an underground chamber. I believe the adventure whetted our appetites for further excitement, and we started the day by planning to investigate more underground work:

"What I can't make out," said Bill, who was fussing with something at the wash-basin, "is how they keep the water out of those tunnels under the river."

"I don't see anything so mysterious about that. They use compressed air to keep the water out, just as in a caisson."

"Yes, I know, but it isn't as simple as all that. Now look at this," and he pushed a glass, mouth down, into the water. Although the glass was completely submerged, the water did not fill it because of the air trapped inside. The water rose to within an inch or so of the top.

"That's just like a caisson," continued Bill; "the compressed air in the top keeps the water down, just as Mr. Squires explained. But now watch me turn the glass on the side." Just as he got the glass near the horizontal, the air went out with a big "gulp," and the glass filled with water.

"See that! Now how in the world do they keep the air in and the water out, with the end of the tunnel open so that the men can dig away the sand and mud ahead of the tube?"

"That question is too much for me," I confessed. "We shall have to have a look at the work, and see for ourselves how it is done. I suppose you don't mind going down under pressure again?"

"Mind that! Not a bit!" exclaimed Bill. "One little accident isn't going to scare me away."

On our way down-town we stopped at the hospital to inquire about Danny Roach. Although we couldn't see him, we were assured that he was doing nicely, and would be fit for work again in a few days.

When we got down to the tunnel-shaft, we encountered unexpected difficulties. The superintendent wouldn't even see us, and we were obliged to go away without a single glimpse inside the yard. The next day, however, we came back armed with a letter of introduction from Mr. Squires. This gave us an audience with Superintendent Brown. But that did not mean admission to the tunnel.

"The rule is strict: 'no visitors allowed'," he said. "I wish for the sake of my friend Squires that I could let you in. But no one, under any pretext whatever, is allowed in that tunnel, except those actually engaged in the work down there."

"Wouldn't the chief engineer give us a permit?"

"No. Others have tried that, but it was no use."

"Then there is absolutely no chance of getting in?"

"None that I know of,—unless," he suddenly added, with a laugh, "unless you would like to go in as 'sand-hogs.' Eh, what?"

"Would we like it!" said Bill, his eyes sparkling. "Come on, Jim, it'll be a great experience."

"Now, I warn you," said the superintendent, "this isn't going to be a lark! You will have to work hard, and I won't take you on unless you contract to work at least a week; if you shirk or fall down on the job, I will fire you on the spot without a cent of pay. Your wages will be two dollars a day because you are green hands, but if you stick to it you may get as much as four dollars a day after a few year's experience, the same as the rest. How is that for a glittering prospect—eh?"

"I'm game if you are, Bill." I had visions of an exciting story for the *Sphere* and a check fully twice as big as the first one.

"Report to the doctor, then, and let him look you over," said Mr. Brown.

"We are safe on that score," I interrupted, "because we have just been down under pressure in a caisson."

"Yes, but you must see our doctor, nevertheless. If he says you are O.K.," continued the superintendent, "you can report to Hughie Smith, the gang boss, at midnight. Be here in time to put on your working togs. We'll supply the boots. You'll have to go on at twelve o'clock sharp, and you work till eight."

"Do you work here all night?" we asked in surprise.

"Most assuredly we do!" he replied. "There is no day down there in the tunnel; it is just one long continuous night. You'd better run home now and go to bed, or you won't be fit to work to-night."

It wasn't exactly what we had bargained for, working nights and sleeping during the day, but we thought we could stand it for a week. We found it very difficult to get to sleep early, and at 10.30 our alarm-clock awakened us after we had put in less than four hours of slumber. It was the hardest thing in the world to shake off our drowsiness, but the spirit of adventure sustained us, and kept us from backing out. We dressed hastily and had a hearty meal in a little restaurant around the corner, and at a quarter to twelve reported to Hughie Smith at the sand-hog house.

It didn't take us long to put on working clothes and boots. There was something weird about the whole affair—the brilliant flaming arc lamps here and there casting jet black shadows around the yard; the clank and rattle of machinery; the sound of escaping air; the buckets that came up out of the tunnel, and the swish of the stuff as it slid out into the big hoppers from which it was emptied into carts that hauled it off to fill some low spot in or near the great city. We didn't have much time to muse over what we saw. A whistle sounded, and we assembled at the mouth of the shaft with the other sand-hogs, where checks were handed out. We were no longer known by name, but merely by the numbers on the checks.

The cage that rose suddenly out of the shaft discharged a

gang of men, and we took their places. In a moment we were at the bottom of the shaft and stepped out into the tunnel, a huge iron cylinder seventeen feet in diameter. It was fairly well lighted with electric lamps, showing the cast iron plating with which it was sheathed. We followed the men down the tunnel to a sort of bulkhead built across the tube. In this bulkhead were the air-locks, two of them, with doors large enough to admit the trucks on which the mud and sand were carried out from the tunnel heading. The men all crowded into one of the locks. It was a rather long, horizontal cylinder with seats on either side for us to occupy while the pneumatic pressure was turned on. Both doors of the locks were closed, and then the gang boss turned on the air gradually. I could feel the strain on my ear-drums as the air rushed in, although I held my nose and blew as hard as I could. When the air ceased hissing, we knew that the pressure in the lock was the same as that in the tunnel. The foreman then opened the door, and we all trooped out. We had to walk a couple of hundred feet before getting to the shield. The boss stationed his men, and then turned to us. Bill had been eagerly waiting for a chance to ask questions. He was full of them, and now he started in; but the boss hushed him up at once.

"Look here, we haven't time for any of that! This ain't no tea-party. You are here to work. Do you understand? Take that shovel there and get busy loading this truck. No loafing now!"

Obediently we started work without further words, realizing that we must depend on our eyes to answer our questions. We saw that the tunnel shield was a sort of a drum-like affair with the ends open, but with a diaphragm dividing it in two in the center. There were a number of sliding doors in this diaphragm, through which the men could pass to the outside of the shield, to dig away the soil in front of the tunnel. We found a chance to step through the diaphragm once and see that the front of it was divided into a number of pockets by plates that ran up and down and crosswise. The men worked in the shelter of these pockets, removing the soil in advance of the shield. Our job, however, was inside the shield, loading the trucks with the sand, or "muck," that was shoveled through the openings in the diaphragm. The trucks, when filled, were hauled away by small electric locomotives, or "dinkies," as they were called.

We worked hard, sustained by the rich atmosphere; but our muscles were not used to such labor, and before long we grew exceedingly tired. Interest in the work about us, however, helped to divert our attention from aches and pains. We observed that the shield was larger in diameter than the lining of the tunnel, and that it fitted over the end of the lining like a cap. We saw also how the shield was moved forward. A number of hydraulic jacks were placed all around the shield between the diaphragm and the lining of the tunnel. Then, when all was ready, the water was turned on in the jacks, forcing the plungers out, and push-

ing the shield bodily forward a distance of about two feet, or just enough to get in another ring of lining. The work required great care because with the jacks the shield was steered and made to move up or down, or to the right or left, so as to follow the course of the tunnel as planned. The tunnel was being pushed through from the other side of the river as well, and, unless the work followed the survey accurately, the headings would not meet properly at the center of the river. Just how accurately the steering was done we learned, many months later, when the shields of the two headings met. One of the shields was four inches lower than the other, but otherwise the alinement was perfect. Think of it! Only four inches out, after groveling in the dark through a mile of silt!

The way the lining was set in place was interesting. There was an "erector," or a sort of hydraulic crane, mounted on the face of the shield, with which the lining plates were picked up and placed in position after the shield had been moved forward. These plates were curved to the arc of the tunnel, and had deep flanges on all four sides through which the bolts were passed that fastened them one to the other. The deep flanges made them very strong indeed.

For four hours we toiled steadily. It seemed eight before the gang knocked off for luncheon. I was disappointed to find that the dawn was only just breaking when we emerged from the tunnel. We hadn't thought about eating, and had brought no lunch-pail. The idea of taking lunch at

four o'clock in the morning would have seemed ridiculous to us. Needless to say, the idea was far from ridiculous now. Hot coffee was served in the sand-hog house, but we were ravenous for something more substantial. There were no restaurants open in that vicinity at that time of the morning. One of the men took pity on us and gave us a few bites of his luncheon, for which we were truly grateful.

He was a fine fellow, an old hand at the game, and he knew all there was to know about pneumatic work. He it was who explained our problem of the tumbler.

"It's simple enough," he said; "the pressure of the water depends on the depth, and so there is more water-pressure at the bottom of the tunnel than at the top; but there isn't any difference worth mentioning in the air-pressure between the top and bottom of the tunnel. If the material out in front of the tunnel was very soft, and we made the air-pressure heavy enough to keep out the water at the bottom of the heading, it would all escape out of the top; and if the air-pressure was just equal to the water-pressure at the top of the tunnel, the water would pour in at the bottom. Just now the material we are going through is clay-like, and we don't have to bother very much about differences of pressure at the top and bottom of the tunnel; but when we go through quick-sand, with very little 'cover' between the shield and the bed of the river, then comes trouble. We don't dare work out in front of the diaphragm, but must open small shutters in the diaphragm and scoop out the sand. That's when we are apt to have

blow-outs. The air will burst through the fluid sand and boil up. Sometimes a burst of air will make the water shoot up like a geyser from the surface of the river."

"What happens when you strike a rock?" Bill inquired.

"We have to blast it out of the way. The worst trouble comes when we strike a ledge at the floor of the tunnel, and have soft silt or quick-sand overhead. We had a job like

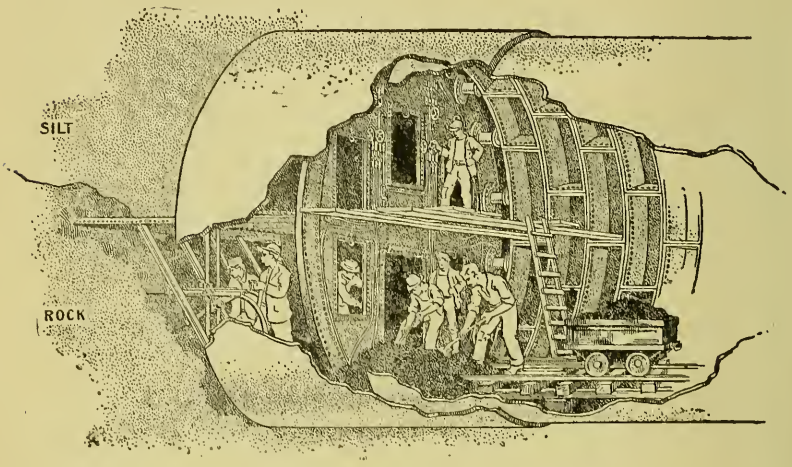


FIG. 6. DRILLING THE ROCK LEDGE OUT IN FRONT OF THE SHIELD.

that in the North River once. A shelf, or 'apron,' was built out from the shield, half-way up, virtually dividing the front of the shield into an upper and lower chamber. Under protection of this apron, workmen crawled out in front of the shield, drilled holes in the rock for mild charges of explosive, and then crept back within the shield and set off the dynamite. After that they had to crawl out again and haul the broken rock away. It was slow

work, because the operations had to be carried on in cramped quarters, and only a little of the rock could be blasted at a time. Fortunately, there was very little rock to pass through. It was merely a reef in the ocean of silt. Before we struck that reef, we found the material so soft that we didn't bother to dig it away in front of the shield, but merely pushed the shield ahead through the silt with the hydraulic jacks."

Our friend was in the midst of his explanations when the signal came to resume work. Our half-hour of respite had seemed like only five minutes. We were aching all over. How could we ever endure the three and a half hours of labor before the next shift came on? Luckily for us, the boss did not pay as much attention to us this time as he did before, and we could ease up a bit on our work without having him bawl out at us to "Git busy there!" every two minutes.

Slowly the hours dragged by. Finally, when it seemed as if we could endure it no longer, the signal to quit was sounded, and we all trooped out. Tired! I was never so tired in all my life, and I was desperately hungry, too. The first thing we did was to hunt up a restaurant, where we devoured such a breakfast as astonished the waiter. Then we went straight home to bed.

CHAPTER X.

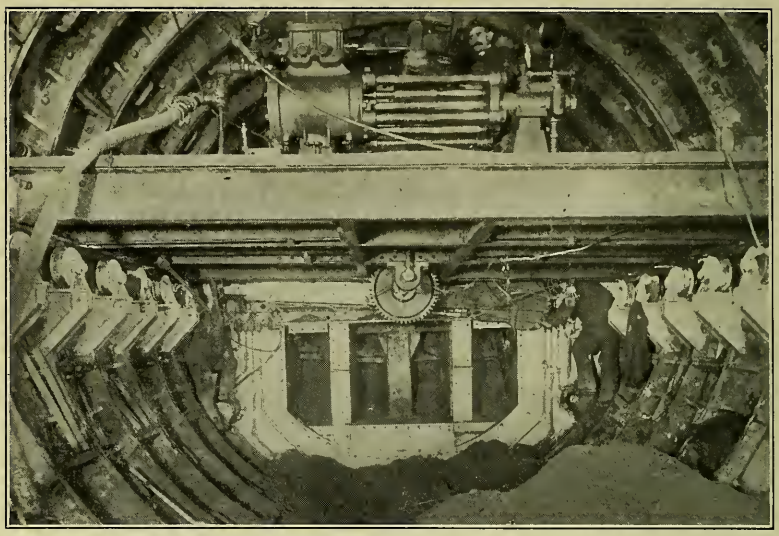
A MAN GOES SKY-ROCKETING THROUGH THE RIVER BED.

ALONG toward the middle of the week, we were shifted to the heading at the other side of the river. The work here did not differ materially from that which we had been doing, but we found it easier to do a day's work that began at eight A. M. and ended at four P. M. than one that took up the hours between midnight and our customary rising hour. We were learning how to swing the shovel to better advantage, and we were not half so weary when our day's toil was ended. We got very well acquainted with the men, and found them a pretty decent sort. To be sure, they "jollied" us a great deal, but we were wise enough to take it good-naturedly.

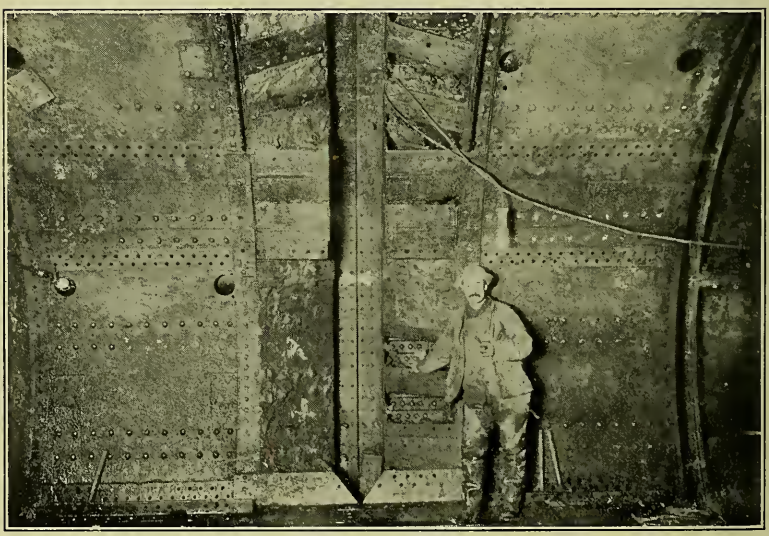
Nothing very exciting occurred until the last day of our contract week. That day started wrong. In the first place, the gang foreman failed to show up, and we went down the shaft without him, taking our regular places. Soon the superintendent came down and appointed one of the more experienced men foreman of the gang. That's where the trouble first started.

We had been having considerable difficulty with boulders in the path of the shield. They had to be broken up

"CLEAR THROUGH THE BED OF THE RIVER AND UP TO THE SURFACE."—See page 88.



VIEW LOOKING TOWARD THE SHIELD, SHOWING THE TRAVELING PLATFORM THAT CARRIES THE ERECTOR.



TWO SHIELDS FROM OPPOSITE SIDES OF THE RIVER MEETING PERFECTLY.

before they could be hauled out of the way. During the night, an extra large boulder had been encountered, and an attempt had been made to blast it. The blasting had failed to make any material impression on the rock, but it had loosened up the silt and mud overhead so that it was in a very shaky condition. Had our foreman shown up that morning, no doubt he would have learned from the foreman of the night gang just what had occurred, and, accordingly, would have proceeded very cautiously; but we went about our work as if nothing had happened.

Several men were outside of the shield at work in the different pockets. The new foreman climbed up into one of the upper pockets, when he noticed a bad leak at the edge of the "apron." The apron in this case was a curved steel plate that projected from the upper part of the shield, like the poke of a sunbonnet, and protected the men below from material that might fall on them. It was supported by slanting braces. As soon as he saw the leak, the foreman called the men to bring up bags of sand and clay to choke up the hole. Two men climbed up through the door in the diaphragm with bags of sand. The first one, "Jerry," was about to hand up the bag, and the other fellow, "Jake," was right behind him, when suddenly, with a sound like a giant cough, the air burst through the silt above the apron. The tunnel had discharged like a pneumatic gun. The air picked up the men as if they had been straws, and flung them headlong into the mud. I happened to catch a fleeting glimpse of all this while I snatched desperately at something to keep

from being blown along with them. At the very same instant, the lights went out, and we were plunged in inky darkness, while we could hear the rush of water pouring into the tunnel. There was a panic at once. Every one started on a mad scramble, stumbling and falling over one another and the various timbers and obstructions, shouting and yelling—a wild run of 400 feet to the locks. Bill and I grouped our way back as fast as we could, hand in hand. My chum had been knocked down and rendered all but unconscious by an ugly blow on the forehead.

It was not until we had all entered the locks and had actually begun to lock ourselves through that our senses returned to us. We were like the Irishman who swam ashore to save himself first, and then swam back to save the other fellow. The foreman, who had fled with the rest, suddenly remembered the responsibility that rested upon him. Hastily he counted noses, and found that two were missing.

"They must have been caught by the blow-out," he said; "we must go back to save them if we can." Candles were procured, and we all went back into the black tunnel.

As we neared the shield, we heard a faint voice calling for help, and we shouted encouragement. The water was rapidly growing deeper, and already it was up to our knees. We found a poor fellow lodged in the mud between the boulder which the night shift had tried to blast and one of the slanting braces of the apron. It was Jake. What had become of Jerry? We could not imagine. We had work enough trying to extricate the man before us. When the

blow-out occurred, he was knocked senseless for a time, but then the black water and mud flowing in through the opening made by the outpouring air ran down over his face, and restored him to consciousness. When he came to, all had deserted him; everything was dark, and he was pinioned so that he couldn't escape, while the black torrent flowing down on him nearly drowned him. To make matters worse, as soon as the tunnel had discharged most of its air-pressure in the blow-out, the silt began to press in upon the shield. This threatened slow torture for poor Jake. Slowly but surely the boulder would crush him. He called and called. He knew that it would not take long for the tunnel to fill with such a river of mud flowing into it. Fortunately, he was in the upper part of the heading, and it would take longer for the water to reach him. He had almost given up hope when he heard us coming back. The task of removing him was not so simple. We managed to free his body, after some work, but his legs were firmly held. There was little time left; the water was rising rapidly.

"Come back," shouted one of the men, "we have got to close the doors in the shield, or the tunnel will be filled."

"What! and leave that fellow out there!" I cried.

"We can't get him out anyway, and if the locks are flooded, we can't get out ourselves!" he said, vainly tugging at the doors. In the progress of the tunnel the shield had slowly turned over so that the track of the sliding door was no longer horizontal, but slanted upward, and the door was too heavy for the man to move it up the incline.

Things were getting desperate. But at last there was a shout of triumph. The foreman had succeeded in prying loose the rock that held Jake pinioned. It was none too soon; the water was pouring in faster than ever. It had reached the "spring line," or the center line of the tunnel; that is, it was 8½ feet deep at the shield. Even when walking along the tracks that were elevated above the bottom of the tube, the water was up to our shoulders; and one or two of the shorter men had to swim.

The rescued worker was placed on a plank and floated to the locks. There was no time to think of closing the doors in the shield, besides they were submerged, and so we could not reach them now. If it hadn't been for the grade of the tunnel, the water would have filled it above the level of the locks. As it was, the water was beginning to slop over the sill of the lock as we splashed up to it.

But what of the other victim of the blow-out? We had found no trace of him anywhere, and there was no possibility of making further search for him.

But when we reached the top of the shaft, you can imagine our amazement at seeing the man who had supposedly perished, sitting calmly in the center of an admiring group of reporters, and telling a most astonishing story—such as was almost beyond belief! When the tunnel discharged like a great air-gun, he had played the part of a bullet, and had been shot *clear through the bed of the river and up to the surface!* Two men were in a rowboat under a dock picking up driftwood, when suddenly a screaming, mud-covered

object shot up out of the depths, rising clear of the water, and dropping back again with a splash. They were terror-stricken; panic seized them, particularly when the object reappeared and struck out after them, but Jerry's cries for help brought them to their senses, although it was some time before they realized that he was actually a human being, and not some inhabitant of the lower regions. They pulled the man aboard and brought him to shore. At first Jerry thought he must be badly hurt. He ought to have been hurt in such a sky-rocket trip as that, but after feeling himself all over carefully, he couldn't for the life of him, find any damage to his anatomy! So there was nothing for him to do but report back for work!

Here was my chance. I rushed for the nearest telephone and called up the City Editor of the *Sphere*.

"Hello," I shouted, "a sand-hog has been blown out of the East River tunnel, clear through the bed of the river. I was right beside him when it happened. Would you like to have me write an article about it? I can get it to you in time for the first edition to-morrow."

"Hey, what's that? Who is this?"

"Why, I'm the fellow that wrote the story about the sky-scrapers last week."

"Don't know you, but whoever you are telephone your story *now*. This is no monthly magazine."

He switched me over to a man who pumped the story out of me almost before I knew it. It was the most sensational incident that had ever happened in tunnel work, and I

had scored a "beat." The next time I called up the City Editor he had no difficulty in recalling me.

Inside of an hour the place fairly buzzed with reporters, but while they were still questioning the men, a breathless boy came running up with an arm full of "extras" containing my story. They sold like hot cakes, and Jerry had the pleasure of reading all about his own curious adventure.

There was no more work done that day. It was the last day of our contract week, and we were more than glad to throw up the job and collect our wages.

CHAPTER XI.

STOPPING A LEAK WITH A HUMAN BODY.

It was sheer luck that brought us back to the tunnel-shaft, a few days later, at the precise moment when a distinguished-looking man issued from the office with Superintendent Brown at his heels.

"Why, hello, here they are now!" exclaimed the superintendent as he caught sight of us. "Come here, boys, I want to introduce you to Chief Engineer Price."

"Aha!" said the engineer, "so you are the boys I have been hearing about. I suppose you want to contract for another week's work, don't you?"

"Well, not exactly, sir," spoke up Bill. "I don't think we care for any more tunnel experiences just now. We have had enough to last awhile, but we thought we would stroll down and see how you were going to clear the mud and water out of that tunnel. Jim and I have been trying to figure it out, but we can't, for the life of us, see how you are going to do it."

"Well, boys, if I weren't in such a beastly hurry just now," said Mr. Price, looking at his watch, "I would like to have a talk with you. You come to my office to-morrow at one o'clock sharp. I want you to take lunch with me. Here is my address," and he handed Bill his card and was off before we had recovered from our surprise.

Just as the clock struck one the next day, we pushed open the door of the engineer's rooms, and were promptly shown into his inner office.

"Good morning, boys," he said cordially, shaking hands with us. "You're on time to the minute, I see. There is nothing I commend so highly as promptness. We shall step right out to luncheon and do our talking there."

The club to which Mr. Price took us was so richly and elaborately furnished that we were quite overwhelmed; but our host soon put us at ease. He wanted to know all about us and what induced us to try our hand at sand-hogging. We told him the whole story from beginning to end.

"And this Uncle Ed, who is he?"

"Why, Edward Jordan, the engineer."

"What! are you 'Eddy' Jordan's nephew? I used to know him when I was at school. We used to have great times together. By the way, your uncle knows quite a little about tunneling, although that is not his specialty in engineering. Didn't he ever tell you about his experience in the Hudson River tube, at the time they had the blow-out that threatened the tunnel?"

"He never told me anything about it," answered Bill.

"That's odd. It happened when they encountered a ledge of rock under the main channel near the New York end. The cutting edge at the bottom of the shield was crumpled against the rock and it was necessary to pass out in front of the shield to do some excavating."

"Oh, yes. One of your men told us all about that and

how they put a steel apron in front of the shield to work under."

"But did he tell you about how they stopped the blow-out with a man's body?"

"A man's body? A dead man?"

"Oh no, he was very much alive. It was like this. The work of erecting the apron took some time. First thing they did after striking the ledge was to force 'poling boards' out into the mud in front of the shield so as to form a sort of roof. Then as they dug away the mud, they built up side walls with 'breast boards' or short upright pieces. Then it was decided to substitute a steel apron for the roof of 'poling boards.' When this had been done, the rock was laid bare for drilling and blasting. But all this took so much time that the mud covering over the tunnel was very much weakened. There is always a tendency for the air to escape between the lining and the top of the shield. There is usually a gap there of an inch or so for clearance, and it is kept plugged with sand bags."

"Yes, we——"

"Of course you know all about that. I forgot that you were sand-hogs. You probably know that while the shield stands still for a short time, the silt retains the pressure in the tunnel, but if it stands a long time, the air that is constantly leaking out loosens up the silt. The river was sixty-five feet deep at that point and the mud was only about ten feet deep over it. Gradually the mud was carried away until there was nothing but water over the shield. As long

as the shield was not moved, there was no danger, but as soon as it was shoved forward for a new ring of lining, the packing of sand bags would be disturbed, first the air would rush out, and then the water would pour in so fast that the tunnel would be swamped. That was the situation that confronted the engineers. The proper course would be to dump a scow-load of clay into the depression hollowed out by the air over the tunnel, and in that way to build an artificial bottom for the river, so as to hold the air in while the shield was pushed forward. But this was in the dead of winter. The clay banks were all frozen. The river was choked with ice. The longer they waited, the larger the depression became. Something had to be done at once. The work of blasting away the ledge in front of the shield was pushed with feverish activity. As soon as a sufficient space had been cleared away the chief engineer decided to risk moving the shield without any cover. A double shift of men was summoned to fight the air and water with bags of sand and clay. Preparations were made to run the air pumps at full pressure on a moment's notice. Your uncle, who was a friend of the chief engineer, asked, as a special favor, that he might be present to watch the operations. When all was ready, the hydraulic jacks were operated and slowly the big shield moved on. As the packing between the shield and the lining was dislodged, the air burst out with a deafening roar. The pressure in the tunnel dropped suddenly and everything was obscured in a dense fog. The men had been standing ready with bags to stop just such an

outflow. The veteran sand-hogs closed in on the work of plugging the leak, but the terrific racket and the dense fog disconcerted the new men, who had never experienced a 'blow-out,' and they stampeded. The foreman had to round them up and drive them back to the fight. The air compressors were working to the limit of their capacity, but the air was pouring out faster than it could be pumped in. Your Uncle Ed was right there in the thick of the battle, piling in the sand bags. But no sooner were they stuffed into the gap than they would be blown right through by the air. All around the lower part of the shield the water was streaming in. All the men could hope to do, was to retard the flow while the shield was being shoved for a new ring of plate. But the air was being lost faster than the pumps could supply it, no matter how hard they worked at plugging the leaks temporarily, until the finish of the "shove." Ammunition was getting low. The sand bags were practically all gone. Men used everything they could get hold of, old clothes, coats, even their shirts were stuffed into that ravenous gap. At one critical moment your uncle Edward picked up one of the sand-hogs and before the fellow knew what was up, he shoved his back against the worst leak. There he stuck with his back to the roof of the shield, pinned fast by the air pressure. My! but wasn't he frightened. Struggle as he would, he couldn't escape. In the meantime the men worked frantically, until the shove was completed, when all air leaks were stopped and the air pressure again became high enough to overcome the

hydrostatic head of the river outside, the man was relieved from his odd position, and the ring of plates was erected. One more shove of the shield, another ring of cast iron lining and the danger spot was passed. A safe covering of mud overlay the shield."

Mr. Price smiled indulgently as he noted the eagerness with which we followed every word of the story.

"Sounds dramatic doesn't it—stopping a leak with a human body, but there is nothing unusual about it. It is frequently done, but the sand-hog your uncle used had never gone through such an experience. It doesn't hurt in the least you know. If only the hole hadn't been so large the other day, Jerry would have stopped the leak instead of shooting through the river and our tunnel would not be flooded with water now."

"How are you going to get the water out?" Bill inquired.

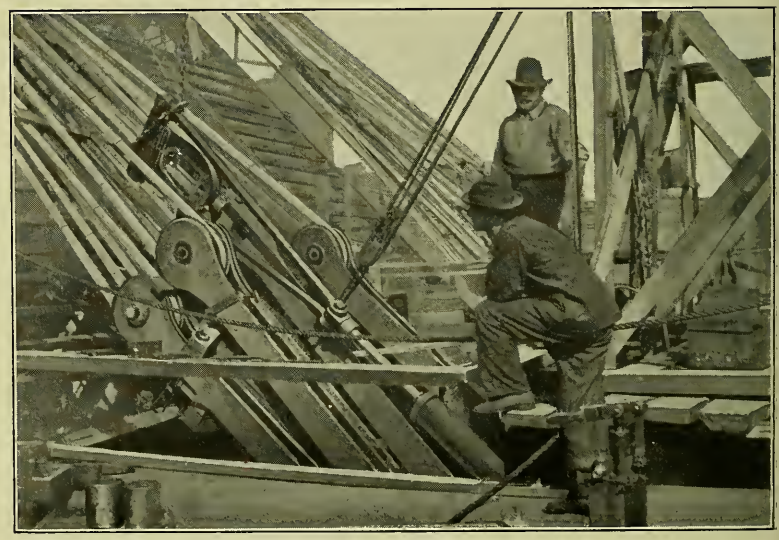
"Oh, that is not such a very difficult job," said Mr. Price. "We have located the hole in the bed of the river, and tomorrow, at slack tide, we are going to sink a tarpaulin over it and dump clay on the tarpaulin. That ought to make a pretty effective seal, and then we shall pump the water out of the tunnel and the air into it at the same time. I will give you a pass to see the work if you like.

"Oh, Mr. Ludlow!" called out Engineer Price to a large man with a long gray mustache who was passing our table. "Sit down here a minute. I want you to meet a pair of very promising young engineers. This is Bill, Eddy Jordan's nephew, and this his chum, Jim. Mr. Ludlow, boys, is the

BUILDING A TEMPORARY FOOT BRIDGE ACROSS THE RIVER.

THREE HUNDRED FEET ABOVE THE EAST RIVER.

DRAWING BACK THE SHOE WITH A HYDRAULIC JACK.



TURNING THE SHOE ON EDGE AND FITTING IT BETWEEN THE EYE BARS.

chief engineer of the new East River suspension-bridge." Then he proceeded to sing our praises to the bridge engineer, much to our embarrassment. "Why, they have been actually groveling in the mud as sand-hogs for a whole week, just to learn something about tunnel work at first hand instead of through books. Such striving after knowledge, such devotion to engineering, should be encouraged. Now, why can't you arrange to have them shown over your bridge?"

"Why, I should be delighted to," said Mr. Ludlow. "Call at my office, boys, and I will give you a letter of introduction to Mr. Blanchard, my assistant, who is in immediate charge of the work."

"Will you, sir?" said Bill eagerly. "Thank you so much. That's the very work we wanted most to see."

And before that luncheon was over, we had met a number of engineers, all of whom took a kindly interest in us, and offered to show us through the various lines of work in which they were engaged.

CHAPTER XII.

SPINNING A WEB ACROSS THE RIVER.

"I SUPPOSE what you are most anxious to see is how the cables are strung," said Mr. Blanchard, as he walked out of his office toward the bridge, after we had presented our letter of introduction. "But what's the use of cables unless you have something to tie them to, eh?"

"You mean the towers," I ventured.

"Oh, no, they couldn't begin to stand up against the pull of those cables. We just put in the towers to *raise* the bridge high enough above the river—something after the fashion of the clothes-poles with which a washerwoman props up her clothes-line. Why, you have no idea what a strong pull there is on the bridge cables. We have to build great masses of stonework, and embed in the masonry enormous steel bars linked together like giant chains, to which the cables are fastened. The anchorages of this bridge are each as long as a city block (225 feet), and 175 feet wide, and when they are finished, they will be built up as high as an eight-story building."

With this impressive introduction, Mr. Blanchard led the way up to the anchorage, and let us see for ourselves the huge chain of eye-bars. They were stringing the cables in separate strands, and each strand was fastened to a separate pair of eye-bars.

As Mr. Blanchard was anxious to inspect the work at the other end of the bridge, he did not stop to explain this just then, but started with us up one of the temporary foot-bridges that ran up, under each cable, to the nearer tower.

It was quite a climb, particularly as we neared the top, where the slant of the footwalk was very steep. The towers, reaching up to a height of 350 feet above the water, had looked very slender from a distance, and hardly strong enough to sustain the weight of a heavy double-deck bridge; but we found on closer inspection that they were made of massive steel, rising 322 feet above the masonry pier.

"They're tremendously strong, aren't they? I should think they would stand up under almost any load," remarked Bill.

"They'll carry the load," said Mr. Blanchard, "but we expect them to sway some, back and forth. The top may move one way or the other, as much as two feet from the upright position."

"Why, how's that?" I queried.

"When the summer sun beats upon the cables, they will grow so hot that it would be uncomfortable to put your hand on them, and you will find that they will have expanded considerably. On the other hand, when the bitter cold winds of winter chill them down below zero, they will contract appreciably. We expect the cables to be twenty or thirty inches shorter in winter than summer. The total change will be greater in the long span between the towers

than in the shorter shore spans from the towers to the anchorages, and so the towers will have to bend to accommodate themselves to this variable pull. In the Brooklyn Bridge, the cables pass over cradles on rollers, so that they can travel back or forth with the cable to allow for these variations in the length of the spans. In this bridge, we are going to let the cables rest directly on the towers, and let the towers themselves bend back and forth, to allow for differences in length of the cable. I don't suppose they will ever bend much more than six inches one way or the other, but we have allowed for a flexure of twenty-four inches."

We followed Mr. Blanchard down one of the steep foot-bridges and up the opposite tower. It was a rather long walk, over a quarter of a mile in a straight line, and considerably more following the curve of the cables, as we had to. The foot-bridges were merely continuous platforms, about nine feet wide, and supported on temporary cables under the four main cables that were being strung. I kept strictly to the center line of that platform, and didn't pay much attention to the boats that were plying back and forth beneath us. The foot-bridges were connected in pairs every five or ten feet, by means of beams, and at various intervals there were cross-walks connecting the south pair of bridges with the north pair. It made my flesh creep to see the workmen walk across the narrow beams between the platforms.

All the time, the wire carriers were traveling back and

forth over our heads, just like spiders spinning their threads across the river. The carriers were merely large pulley-wheels connected to traveling-cables. The wire was looped over the pulley-wheel, and as the wheel traveled across, it would string two lengths of wire at once.

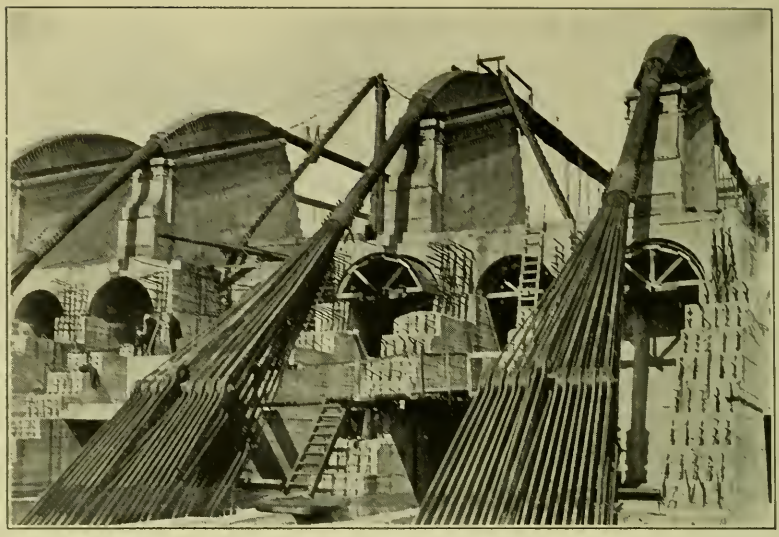
When we had reached the opposite side of the river, Mr. Blanchard explained the wire-stringing process. The steel wire was about half the size of a lead-pencil, but it was strong enough to lift forty men. It was wound on enormous reels weighing four tons each, and with 80,000 feet of wire to the reel. When the cables were finished, they would be nearly two feet in diameter, 21¼ inches, to be exact. Each cable was made up of 9472 wires, strung in thirty-seven separate strands of 256 wires each. Altogether, in the four cables there would be 23,132 miles of wire, or enough to go nine-tenths of the way around the earth.

The wire in a strand, he said, was looped around "shoes" at each end of the bridge, and ran in a continuous length, like a skein of silk. When the strand was completed, the ends were spliced together. When the strand was started, the wire was temporarily fastened at one end and passed around the shoe. Then it was slipped over the carrier, a signal was given, and the cable started, and the carrier proceeded merrily on its way across the river. When it reached the top of the first tower, the lower reach of wire was gripped and hauled up until adjusted as to tension, so that the sag would correspond with a standard guide wire.

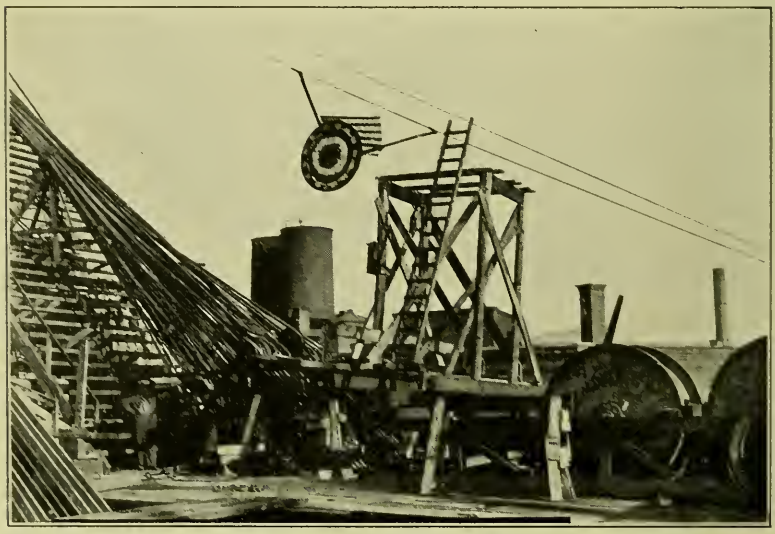
Then it was clamped, and the signal was sent to the next tower, where it was similarly gripped and adjusted. This done, a signal was sent on to the anchorage, where the final adjustment took place. As soon as the carrier released this wire, it took back with it a pair of wires of another skein, which gave time for adjusting the upper reach of wire just strung. The wires were laid at one side of the position they were to occupy in the final cable, and when the strand was completed, it was moved out of the temporary rollers upon permanent shoes. The work of splicing the ends of the strand together usually took about five minutes. The shoes on which the strands were built up were horizontal. When a strand was completed, the shoes had to be drawn back by a hydraulic jack, turned on edge, and pulled back between a pair of steel eye-bars. Here they were made fast by a cross-pin. As the carriers strung two wires at a time, it took only six days to complete a strand. The wire was drawn through heavy oil and graphite, to prevent rusting while the cable was being made up.

We spent many hours on the bridge, examining the work, just how many I do not know; but it did not seem long before we heard several factory whistles, which warned us that it was five o'clock, and quitting time. We followed Mr. Blanchard down to the wash-room, and began to wash up. We were on the Brooklyn side, and as I was washing my hands, I looked over across the water to the tall bridge-tower on the New York side. A thin wisp of smoke was curling up from the very top of the structure.

"MR. BLANCHARD DIDN'T STOP FOR ARGUMENT BUT RAN ACROSS THE BRIDGE."—
See page 104.



EACH STRAND FASTENED TO ITS OWN ANCHOR CHAIN.



STRINGING THE LAST PAIR OF WIRES ON A CARRIER BEARING THE STARS AND STRIPES.

"That tower looks just like a factory chimney," I remarked to Mr. Blanchard.

"Eh, how's that?"

"Don't you see the smoke coming out of the top of it? It seems to be getting thicker."

Mr. Blanchard took one look at the tower, then rushed to the telephone and rang up the office on the other side; but could get no answer. He rattled the receiver hook wildly, growing more excited every moment. Finally, he threw the instrument down violently, and tore out of the room without a word to us. We didn't stop to replace the receiver on the hook, but followed him as fast as we could up to the top of the Brooklyn tower, and then along the foot-bridge to the other side. The smoke was pouring in dense volumes from the tower now, and we could see the flames that were eating up the woodwork. It seemed like an endless run across that long foot-bridge. I hadn't time to think of getting dizzy now. My eyes were on the blazing tower, that seemed miles away. Down below us a fire-boat was screaming, and the clang of fire apparatus showed us that the fire-department had responded promptly. I could see that quite a crowd of men had collected and were trying to put out the fire.

We were on the north foot-bridge, and just as we neared the burning tower, a gang of men rushed down the foot-bridge and across the small connecting bridge to the south foot-bridge. They had tools with them, and apparently their idea was to cut off enough of the timber to prevent

the fire from creeping across the foot-bridge to the Brooklyn side.

"Come back here, you," yelled Mr. Blanchard, when he saw what they were up to. They were so intent on their work that they didn't hear him. At any rate, they didn't heed, but started right in chopping off the planks. Mr. Blanchard didn't stop for argument, but ran across the bridge and began hauling them back by main force. He was so excited he could scarcely speak. "What is the matter with you?" he cried; "don't you know the fire will burn through the cables and drop you, foot-bridge and all, into the river?"

It finally dawned on them what he was after, and they scampered back, Mr. Blanchard bringing up the rear. Just as he was half-way between the two foot-walks, the cables gave way, and down crashed the south bridge. The connecting cross-walks gave our bridge a yank that sent us all sprawling. Bill, who was near the edge, almost rolled overboard, but one of the men grabbled him by the seat of his trousers just as he was teetering over the brink, and hauled him inboard. I didn't see that incident because my attention was fixed upon Mr. Blanchard. The cross-bridge had broken in the middle, and as the broken end sprang up, Mr. Blanchard was nearly slung off by the recoil. But he clung on desperately until some of the men had recovered sufficiently to seize him and drag him up to safety.

The fallen foot-bridge did not drop into the river, but was caught in the tangle of suspended cables. Some of the burn-

ing timbers dropped into the water, narrowly escaping a ferry-boat that was passing under at the time. There was nothing for us to do but to run on up to the tower and give what aid we could there, in fighting the fire. Things were in a pretty bad way. The cotton-waste and oil-soaked timbers, and the barrels of tar and paint and oil, made the very best of fuel, but to fight the fire there was only a single barrel of drinking-water, which had already been used to no avail. The fire-boat couldn't begin to reach us, and fire-engines about the base of the tower were helpless. Some of the firemen tried to drag the hose up the long stairways to the top of the tower, but when they finally did reach the top, and gave the signal for the water to be turned on, the hose burst, and all their labor went for naught. A second hose line was made of better stuff, but only a weak, sickly stream trickled out of the nozzle, because the engines were scarcely powerful enough to pump water so high, even when a number of them were coupled up in tandem. A few of the firemen had hand-extinguishers with them, which held the blaze in check for several minutes; but that ammunition gave out soon, and it was evident that we would have to abandon everything and run.

That retreat was an exciting one. The fire had spread to the northern side of the tower, and as we ran down the stairway, blazing brands kept dropping on us. To add to our peril, there were several barrels of bolts at the top of the tower, and these were heated to redness in the fire, and, as the barrels and flooring burned away, they be-

gan to drop down upon us. I didn't know at what moment a heavy bolt might strike me on the head and lay me out. A man in front of me had his clothing set afire by an incandescent bolt, which fell on the edge of his coat-pocket and hung there a moment. We were not half-way down the tower when there was a crash, and the north foot-bridge fell; but we were so busy dodging firebrands and bolts that we didn't even pause in our rush down the stairs.

When I reached the ground I didn't stop running.

"Hey, come back. What are you afraid of," Bill called after me.

"I've got to find a 'phone."

A man tried to stop me. I recognized him as a reporter for a rival paper and dodged him.

The *Evening Sphere* did not score a "beat" that day but the story we published contained details not to be found in any other paper, and although not so lurid as some accounts that appeared in the yellow journals it was absolutely true.

That fire was one of the oddest the New York fire-department ever had to tackle. They could really do nothing but let the fire burn itself out at its own sweet will.

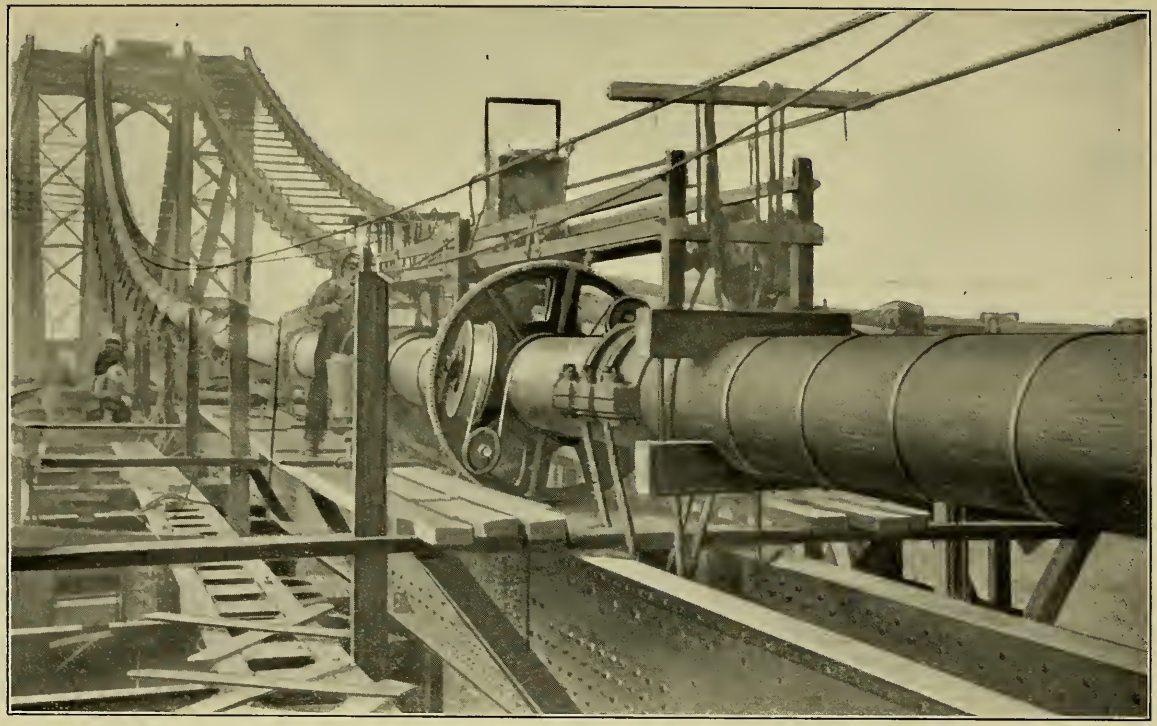
When we went around to see Mr. Blanchard a few days later, he explained to us just what damage had been done to the main cables. It was evident that the cables had been heated red hot during the fire, because they were badly burned and flaked. A number of wires would evi-

dently have to be cut out and replaced with new sections. Some of the less seriously injured wires were cut out and sent to have their strength tested. These tests were very favorable, and showed that the cables were not half so badly damaged as it was feared that they might be.

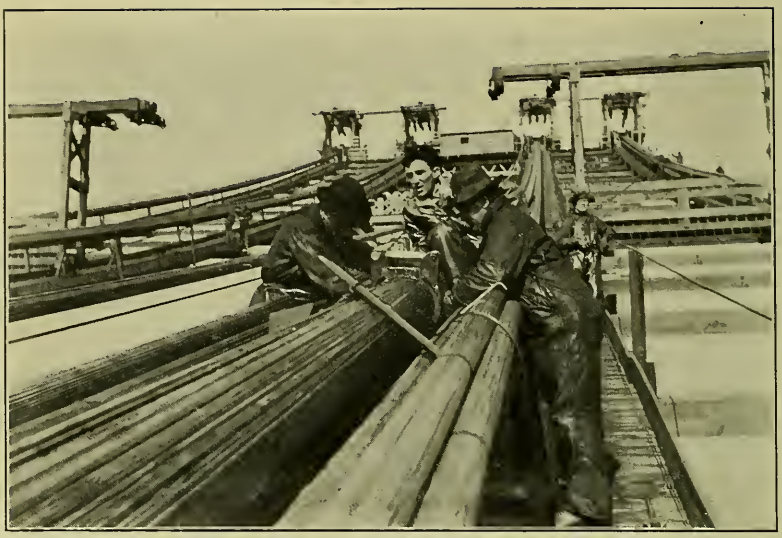
Near the end of the summer, we visited the bridge again, so as to watch the cable-winding process after all the strands had been strung. First, several strands were squeezed together with crescent-jawed tongs, and fastened, at intervals, to form a core for the cable. Then the other strands were grouped about them and fastened temporarily. After this, the wire-winding machine was mounted on the cable. This was a large gear-wheel in two parts, bolted together about the cable. A traveler arranged to move along the cable carried a small electric motor that turned a pinion or small gear-wheel, fitting into the large gear, and in that way made the gear rotate around the cable. A spool of wire on the gear was caried around with it, winding the wire around the cable. A brake on the spool kept the wire under a constant tension. After the wire was wound, a steel sheathing made in half-sections was bolted about the cable. "Every so often" a collar was applied to the cable, and suspender cables were attached to them. To these suspenders, floor beams and girders were to be fastened, and on them the double deck of the bridge was to be built up.

To-day, at any time, you can see a procession of trucks plodding over the bridge, with a string of hurrying trolleys

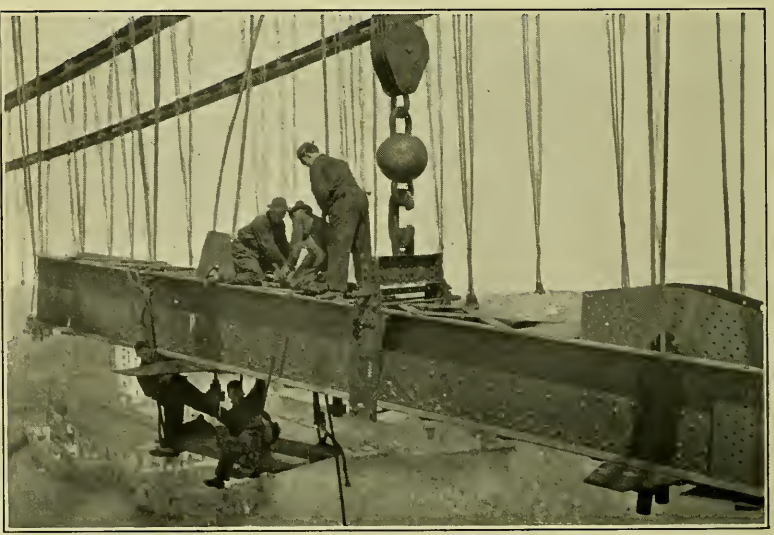
and rushing elevated trains loaded to the limit of capacity with human freight, all supported by the combined strength of those thread-like wires that were spun by human spiders across the East River.



A SPOOL OF WIRE ON THE GEAR - - - - WINDING THE WIRE AROUND THE CABLE.—See page 107.



"SEVERAL STRANDS WERE SQUEEZED TOGETHER - - - - TO FORM A CORE."—
See page 107.



SECURING THE GIRDERS TO THE CABLES.

CHAPTER XIII.

CARS THAT TRAVEL SKYWARD.

BILL and I were sauntering down Broadway one day, when a man suddenly grabbed me by the arm. "Hello!" he cried, "aren't you the boys that blew in from the clouds up at the top of the Manhattan Syndicate Building?"

"Why, how do you do, Mr. Hotchkiss," we both exclaimed.

"I'm well, thanks. But where have you been all this time? Why haven't you been around to see me?"

"We have really intended to," apologized Bill, "but you know there is such a lot of interesting work going on in New York, and we have had so much to see—"

"So much to see? So you are still at it, are you? Mr. Squires told me about the narrow escape in the caisson, and I had about concluded that your experience there had cured you of some of your inquisitiveness."

"We have had a worse experience than that. We were in a pretty bad blow-out in one of the tunnels under the river."

"You don't mean the time that fellow was blown through the river-bed?"

"Yes, we were right alongside of him when it happened; and then we were on the new bridge when it took fire."

"What!"

"Yes, we had quite a time of it, dodging embers and red-hot bolts all the way down the tower."

"Good gracious!" exclaimed Mr. Hotchkiss, "if I had known what 'hoodoos' you were, I would have 'shoo-ed' you right out of my building! Why, you are positively dangerous to have around! Come in here quick, before a cyclone strikes us, or a safe falls on our heads!" Mr. Hotchkiss hustled us into a restaurant. "I want you to lunch with me, and tell me the whole story of your experiences. Three narrow escapes in succession! and here I was just going to send you over to another job. Now, I don't believe I dare assume the responsibility."

"We have had some rather exciting times," I admitted, "but I thought that they were very common in big engineering jobs."

"There is real danger in all big work, but such a run of accidents as you have had is decidedly out of the ordinary; and if you keep on, you will get so bad a reputation that no one will want you around."

"But how can we help it?"

"I don't suppose you can. It is about time your luck turned, though. I'll try you on this next thing, anyway, and see whether you can't come off without an accident. As a matter of fact, I can't imagine what *could* happen this time."

"What is the job?" asked Bill, eagerly.

"There are all sorts of transportation systems in this

town," began Mr. Hotchkiss, "to bring New York's teeming population to and from work every day. The trolleys, or surface lines, carry something like two million passengers per day, and the elevated railways nearly a million and a half, while the subways take in just about a million fares. But there is a transportation system here in this city that carries more than all the rest put together—eight million passengers per day."

"Eight millions! What, here in New York?"

"Yes, in Manhattan alone."

"Why, I thought there were only five million people all told in Greater New York."

"People, yes, but I said passengers. One man could be a dozen passengers if he took a dozen trips in a day. Yes, sir, it is the greatest and busiest transportation system in the world, yet it doesn't take in a single fare. What's more, it is one of the safest forms of transportation. Have you guessed what I am talking about?"

"It's too much for me," I confessed.

"You don't mean the elevators, do you?" queried Bill. "They are not any too safe, from what I hear."

"That is exactly what I do mean, and I will prove to you that you are safer riding on an elevator than walking the street. On the average, there are no less than three hundred killed and many thousand injured on the streets of New York every year. In ten years, there have been only thirty-eight killed and two hundred and seventy injured in elevators in Manhattan, and when you consider that there

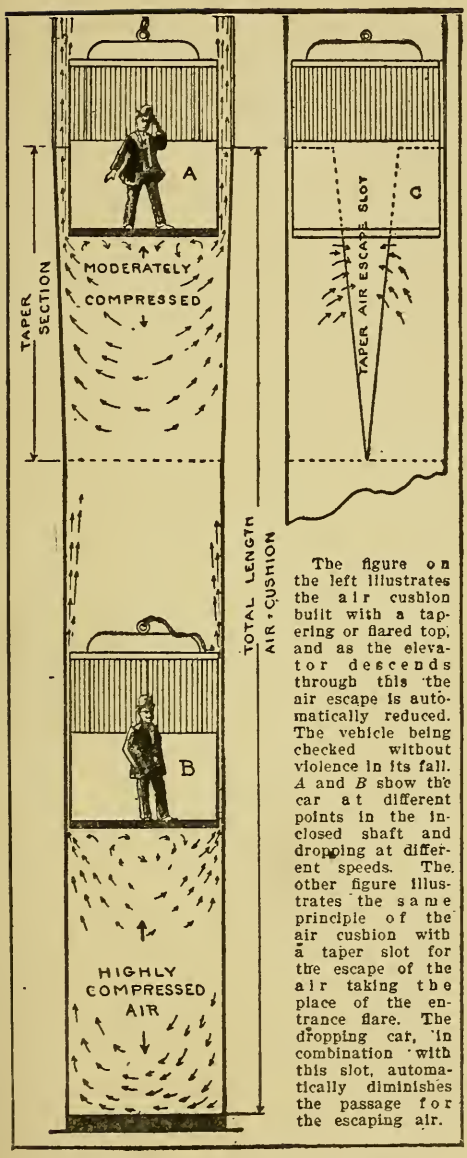
are nine thousand passenger-elevators and sixteen thousand freight-elevators in the borough, running up and down all day, the wonder is that the accidents are so few. Why, if you put all those elevator-shafts together, one on top of the other, they would reach five hundred miles in the air. That would give you a pretty good start toward the moon. And eight million passengers! That is more than all the railroads of the country carry in a week; and railroad injuries run up into the thousands every year. In the Manhattan Syndicate Building, we are going to have the finest system of elevators in the world, all driven by electricity, a regular railroad system, with 'locals' and 'expresses'—some of them running up to the twenty-eighth floor without a stop."

"It must take an awful lot of power to lift an elevator," I remarked.

"Not as much as you think. In fact, it often takes more power to run an empty car down than a partly loaded one up."

"Why, how can that be!" we both exclaimed in astonishment.

"It is like this. A car is always balanced with a counterweight. The cables that run up from the top of the car pass over a set of sheaves or pulleys at the top of the shaft, and at their other ends they are attached to the counterweight. Usually the counterweight is made heavy enough to balance the weight of the car with half a load of passengers. Now, if the brakes should give way on the wind-



The figure on the left illustrates the air cushion built with a tapering or flared top, and as the elevator descends through this the air escape is automatically reduced. The vehicle being checked without violence in its fall. *A* and *B* show the car at different points in the inclosed shaft and dropping at different speeds. The other figure illustrates the same principle of the air cushion with a taper slot for the escape of the air taking the place of the entrance flare. The dropping car, in combination with this slot, automatically diminishes the passage for the escaping air.

FIG. 7. THE "AIR CUSHION."

ing-drum at the top of the shaft while a car is standing empty halfway up the shaft, it would actually fall *up* instead of down, because it would be so greatly overweighted by the counterbalance. You see, all the motor has to do is to move the difference in weight between the car with its passengers and the counterweight; and this can never equal more than half the weight of the passengers. But I don't suppose you would find our elevator system half so interesting as the one I am going to send you to. The only uncommon thing we have is an 'air-cushion,' but that

is not very unusual any more. In fact, the first air cushion was installed twenty-five years since.

"By an air-cushion, I mean," he continued in answer to our question, "a scheme for retarding the car in case it should fall by any mischance. The bottom of each shaft is sealed in with air-tight steel doors, so as to make a rectangular pocket in which the car fits like a plunger in a cylinder. Now, if the car should drop into that pocket at high speed, it would compress the air under it to such an extent as to form a pneumatic cushion that would check its fall. Our highest elevator-shaft will be six hundred and eighty feet high, the highest continuous elevator-shaft in the world, and, as you can imagine, a car would be traveling if it fell that far! We don't dare to make the stop too abrupt, for it would hurt the passengers, and then, too, it would be liable to burst out the doors, so we don't make too close a fit of the car floor in the shaft. But that means that we have to extend the air pocket to a considerable height. On those high shafts, the air pocket extends up one hundred and thirty-seven feet, or ten stories. You could cut the cables with the car at the top of the shaft and let it fall. It would be making something like one hundred and thirty-two miles per hour when it splashed into the air pocket, but when the air was compressed under it, and squeezed up between the car floor and the walls of the pocket, it would retard the car to such an extent that it would settle down to the ground without a serious jar."

"Has any one ever tried it?" I inquired.

"Oh, yes, it has been tried often enough. The designer of our elevators is going to make the trip himself to prove that everything is all right."

"Oh, say! could we go with him?" put in Bill, excitedly.

"What! with your reputation! Well I should say not!"

"But there isn't any danger, is there?"

"No, no danger whatever," said Mr. Hotchkiss. "Yet you never can tell. A man was fatally injured in a test like that once, and you couldn't guess why."

We shook our heads.

"Because, instead of standing, he sat in a chair! You think I am joking, don't you? but I am perfectly serious, I assure you. I'll tell you how it was. If you should drop freely for a hundred feet, and then take twenty-five feet in which to come to a stop, you would have to lose speed four times as fast as you gained it; and so, while you were losing speed, you would be adding four pounds to every pound you weigh. If you weighed one hundred and fifty pounds normally, you would suddenly find yourself weighing six hundred pounds more, or seven hundred and fifty pounds altogether. The weight would be so well distributed that you could stand it if you kept your legs firmly braced, but it would be more than a frail chair could endure. That is how it was in the case I spoke of. The chair was smashed by the suddenly increased load, and the man was fatally injured by one of the splinters."

"But if that is the only danger," persisted Bill, "I don't see why we couldn't take the trip. We wouldn't think of

sitting down. I'd like to see how it feels to fall five hundred feet in an elevator."

"You wouldn't enjoy it. I dropped twenty feet in an ordinary elevator before the safety-catches stopped the car, and I don't care to do it again. Why, do you know, that car fell so fast I couldn't catch up to it! I must have given a sort of involuntary spring when the car first started, because my feet were a foot off the floor all the way down. Of course I was falling all the time, but the car kept ahead of me until it stopped. Then down I went in a heap on the floor. It was all over in an instant, but I lived a lifetime in that instant, wondering whether the safety-catches were going to save me. The elevator man, who was the only other one in the car, had evidently jumped too, because his head was up against the roof all the way down. No, I don't believe you would enjoy the experience, and I assure you that I won't let such unlucky scamps as you two try it. Something would surely happen!"

"What is that other elevator you were going to tell us about?"

"I am not going to tell you about it. I am going to let you see it for yourselves."

He took out his card, wrote an address on the back of it, and a word of introduction to a "Mr. Williams." "Now show that to Mr. Williams, and he will let you see something that will interest you, I think. Don't forget to come back and report any adventures you may experience."

When we reached the address to which Mr. Hotchkiss

sent us, we were surprised to find, instead of a finished building, a fenced-in lot in which they were still at work upon the foundations.

"This can't be the place," said Bill. "They would hardly be putting in the elevators before the building was started."

"Maybe he meant next door, in that skyscraper," I suggested.

Fortunately the elevator starter of the next building happened to know the Mr. Williams for whom we were looking, and sent us back to the adjacent lot. "You will find Williams on the job over there. He is superintending the driving of the deepest bore on record."

That puzzled us all the more, as we couldn't see, for the life of us, what that had to do with the construction of an elevator. Sure enough, when we got there inside the fence and were directed to Mr. Williams, we found that he was overseeing the sinking of some sort of a shaft. A jolly individual he was, exceedingly fat, and well bespattered with mud. He waddled over to us, looked at our card of introduction, then shook us heartily by the hand.

"So you've come over to see how we dig a hole, have you? We are down two hundred and sixty feet in one shaft, and we still have to go one hundred and five feet more; three hundred and sixty-five feet, think of it! How is that for a hole, and only twelve inches in diameter, too?"

"But what has that to do with elevators?" we asked.

"Why, this is to be a plunger-elevator. Didn't Mr. Hotchkiss tell you?"

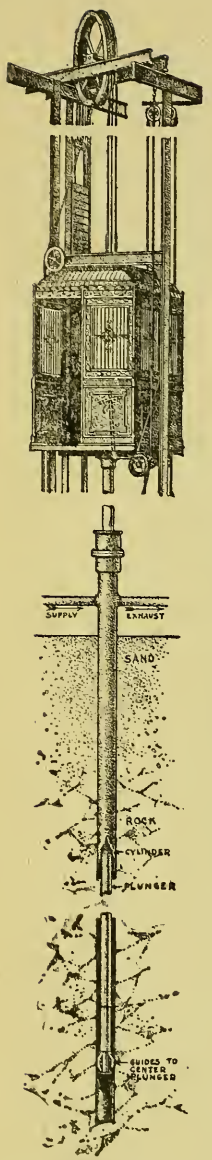


FIG. 8.
A PLUNGER ELEVATOR

Probably most of the boys who read this story know what a plunger-elevator is, but we were rather green, and had to be told. "In each of these deep holes," explained Mr. Williams, "we are going to fit a steel cylinder, nine inches in diameter inside, and closed at the bottom. Within the cylinder there is to be a plunger six and one-half inches in diameter. The plunger is going to pass through the stuffing-box at the top of the cylinder, just like the stuffing-box of a steam-cylinder where the piston comes out. The plunger is fully as long as the cylinder, and upon it the elevator car is mounted. Now, when water is let into the cylinder under pressure, it forces out the plunger, raising the car. What surprises most people is that the plunger does not have a piston-head on its lower end, but is merely a straight piece of steel tubing down to the very bottom, where it is closed with a cap, and has two or three guides on it to keep it centered in the cylinder. When the water is forced in, it exerts a pressure in all directions on the cylinder as well as on the plunger, but nothing can yield to that pressure except the bottom of the plunger, which is raised,

and so pushes the elevator car up. I will take you over to the next building and show you the whole thing in a minute, as soon as you have seen how we sink the shafts."

They were hauling up one of the boring tools just then. It was on the end of a cable attached to a "jumping" machine. Slowly the cable was wound up, and the length of time it took to raise the tool gave us some idea of the enormous depth to which the shaft had already been sunk. When the tool finally came up, we found that it was flat, with a cutting edge something like a chisel. It was pretty badly worn, and a newly sharpened one was put in its place; then down went the tool into the long, deep bore. When it reached the bottom, the line was pulled up until the tool scarcely touched, after which the machine was started, and drilling was resumed. Mr. Williams told us that the tool would not be allowed to hit the rock with hammer-blows like a pile-driver, for it would be sure to turn off sidewise and follow a seam or fault, making a crooked hole. Instead the tool was dangled so that it just barely touched, then, as it was jumped by the machine, the stretch of the cable at each yank would let it strike the rock with a light, springy blow that could not turn out of line; at each blow of the tool it was turned around slowly, so that it would pound out a circular hole. The rock dust was carried to the surface by forcing water into the bore, so that it was a rather mussy job.

"Before we came to solid rock," explained Mr. Williams, "we had to go through about eighty feet of sand,

and the boring was then done with a water jet. This steel tubing," he said, pointing to the lining of the hole, "was sunk into the sand by forcing water at high pressure against the sand through a jet placed in the bottom of the tubing. The water loosened the sand, and it was carried up and out of the hole with the overflow."

After we had seen our fill of the shaft-sinking, Mr. Williams took us over to the next building, and showed us how plunger-elevators are operated.

"These elevator-shafts are not nearly as long as the ones we are building next door. They are only two hundred feet high."

We watched one of the elevators go up, pushed by the light plunger of hollow steel only six inches in diameter. Beads of water trickled down the black, oily surface. As the car went up higher and higher, the slender plunger began to sway as if it were a flexible rope. The car was carrying a heavy load of passengers, and I supposed that that was the reason for the unsteadiness of the plunger.

"It does not seem to be standing the weight very well," I said. "It looks almost as though it would buckle."

"'Weight!'" he quoted. "Why, that plunger is not doing much more than to carry the passengers. The counterweight balances about eighty per cent. of the weight of the car and the plunger. I don't know exactly what these plungers weigh, but in our elevators next door they will weigh close to five and one-half tons. If you loaded one of them on a truck, it would take four horses to draw it.

But if the cables to the counterweight should break, the car would buckle and crumple up that tube as if it were made of rubber."

"That would break the force of the fall, at any rate," remarked Bill.

"Yes, if the tube didn't snap in two, and a jagged piece of it pierce the floor of the car, and injure one or two of the passengers."

"But suppose the plunger broke off and the counterweight cables didn't?" I suggested.

"Why, the car would be relieved of the weight of the plunger, and it would shoot up to the top of the shaft like a rocket. But an accident like that is next to impossible. Yet I did once hear of a case when a car was undergoing repairs. In overhauling the car, the plunger connection had been carelessly loosened without fastening the car down, when suddenly, without any warning, the strain of the counterweight wrenched the car free from the plunger, and up it shot, smashing itself free at the top of the shaft, and then falling down to the bottom again. But such a combination of carelessness would probably never happen again, and the plunger-elevator can be regarded as a pretty safe kind."

Mr. Williams then showed us through the power plant, and explained how the pumps kept the pressure tank up to the proper pressure, and that each tank had some air trapped in it which acted as a sort of spring, so that, when the elevator man turned the valve lever and the water rushed into the plunger cylinder, it was forced out at a

constant pressure by the air; and when he turned the valve the other way, the water poured out of the cylinder into a reservoir, being squeezed out by the weight of the car and the unbalanced weight of the plunger. When the pressure in the tank fell too low, a pump would start up automatically and pump water out of the reservoir into the pressure tank until the desired pressure was restored.

Fortunately no accident befell us on this occasion, and we had a very tame story to report to Mr. Hotchkiss. But although there was nothing very thrilling, and deliciously exciting about elevators and "jump" drilling, we felt that we had learned something worth while; also it made an interesting page in the diary that I was keeping.

THE HEADFRAME OF A SHAFT IN CENTRAL PARK.

WATERPROOFING A TROUGH AT IRONDEQUOIT CREEK CROSSING OF THE AQUEDUCT.

AT WORK ON THE OLIVE BRIDGE DAM OF THE AQUEDUCT.

CHAPTER XIV.

QUENCHING A CITY'S THIRST.

When a country boy visits New York, about the last place he wants to see is the park, and then all he cares about in the park is the "Zoo." Thus, Bill and I took in nearly all the other sights before we went up to see the little patch of make-believe country in the center of the big city. What struck us as of particular interest was, not the rolling lawns, nor the lake, nor the winding paths through the woods, but something that had no business in the park at all. It was right alongside one of the sunken "transverse" streets that runs across the park. There was a high board fence inclosing a yard with several sheds, and a wooden tower that was very evidently the head-frame of a shaft.

We ran to the bridge across the "transverse" to see what was going on. As we watched, a cage rose quickly to the top of the head-frame, a car tilted forward, its end gate swung open, and out poured a load of broken rock into a large hopper beneath. Then the cage started down again, dragging the car back with it into the shaft. It was a rather deep shaft, too, judging by the length of time that the cable was unreeling. Down in the "transverse" below the hopper was a cart taking on a load of rock.

"I wonder what it can be?" queried Bill, excitedly.

"A new subway, maybe," I responded. "They have been talking about one lately." But a man who was leaning over the rail beside us broke in with the information that it was the new aqueduct.

"Oh, yes," I chimed in, "Mr. Price told us we must surely see it. Don't you remember, Bill?"

"It's a whale of a job, too," said the stranger. "The biggest thing of the kind ever undertaken. There never was anything to compare with it."

"How about the Roman aqueducts?" I put in.

"A mere trickle of water," he said, contemptuously. "Why, this aqueduct is going to be fourteen feet in diameter. Yes, seventeen feet in some places; and when it is entirely completed and worked to its fullest capacity, it can furnish us every day with five hundred million gallons of water, brought here all the way from the Catskill Mountains. It is one hundred and twenty-seven miles from the proposed upper lake down to the reservoir in Staten Island. That's quite a river, now, isn't it? While with the five hundred million gallons that we get now from the present systems, there will be enough to supply every man, woman and child in Greater New York with two hundred gallons per day."

"How much is two hundred gallons?" I inquired.

"About three bath-tubfuls, all good, clear, clean water."

"But what in the world do they expect to do with all that water?"

"At present, they are not going to complete much more than half the work in the mountains. They are merely making provision for the future. I suppose, in fifty years' time, New York will be so large that even this supply of water will not be enough, and then people will have to tap Lake Champlain, or Niagara, or something. You young fellows ought to go up to Ashokan, and see the work they are doing there. They are building a dam a mile long and two hundred and twenty feet high, and then there will be dikes, and embankments, and weirs, making, altogether, about five and one-half miles of masonry and earthworks that will turn a whole valley into a lake. Why, they have had to move seven villages and thirty-five cemeteries to make room for that lake.

"Cemeteries!" I exclaimed.

"Yes, they have to dig up and rebury twenty-eight hundred bodies. On the other side of the mountain, they have planned for another large lake, and the two lakes are to be connected by a tunnel. From the Ashokan reservoir, they are going to convey the water by means of pipe-lines and tunnels down to the Hudson River at Break Neck Mountain, and there, to my mind, is the most wonderful thing of the whole system. They are going to dip under the Hudson River with a tunnel eleven hundred feet below the surface."

I had been suspecting that the man was exaggerating a good deal, and now I was sure of it. "Come off," I interrupted, rather impertinently. "You can't 'put that over'

on us. We know something about tunneling and excavating in this neighborhood, and we know that the deepest hole ever dug in New York didn't go one hundred and ten feet below water-level; and then the air-pressure in the caisson was so heavy that the men could only put in two hours' work a day."

"But," explained the man, "this is not caisson work. The 'siphon' under the river is being put through solid rock, where they do not have to bother with pneumatic pressure. Why, it is just because they wanted solid rock that they had to go so deep. This tunnel is being built to last forever. Nothing short of an earthquake can hurt it, and the chances of an earthquake in New York are pretty slim, according to what geologists tell us."

"It seems to me it is pretty dangerous work," put in Bill. "Suppose they should strike a break in the rock. Just think with what pressure the water would pour in! They would drown there like rats."

"You may be sure they thought of that before they started excavating. Borings were made to find out what sort of rock they had to go through. First they started boring from a scow anchored in the middle of the river. They had all sorts of trouble, too. Once a string of canal-boats banged up against the scow and broke it from its mooring, smashing the drill. Then another time the ice carried the scow off. Finally, they gave it up after drilling down seven or eight hundred feet without coming across anything but an occasional boulder. It seemed as if that

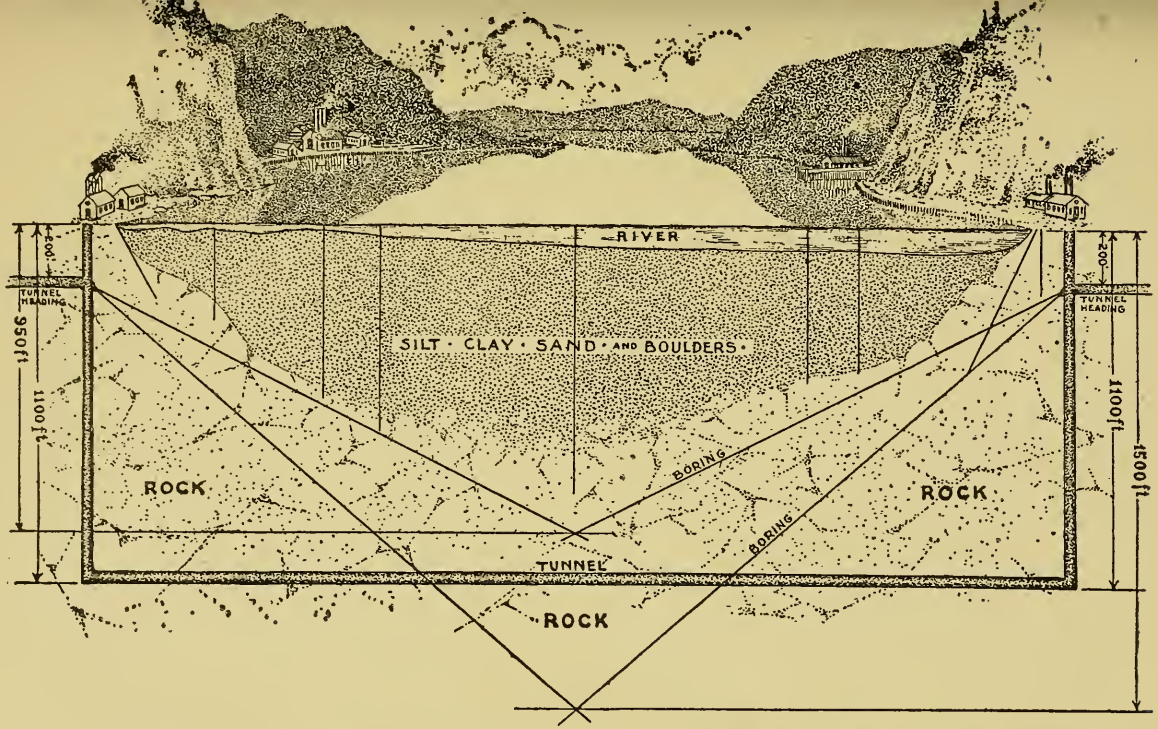


FIG. 9. THE AQUEDUCT TUNNEL UNDER THE HUDSON RIVER. IN SEARCH FOR GOOD ROCK INCLINED TEST BORINGS WERE MADE FROM EACH SIDE, MEETING AT 950 AND 1500 FEET BELOW THE SURFACE.

river had no bottom at all. At any rate, it was not worth while trying to reach it from so unsteady a base as a scow, so, instead, they began drilling on a slant from each side of the river, at such an angle that the drill holes would meet at a depth of about fifteen hundred feet below the middle of the river. The drills went through rock all the way, and no water was struck. So then they bored another pair of test holes that met at a depth of nine hundred and fifty feet, going through solid rock all the way. That decided them that it would be perfectly safe to run the siphon through at the eleven hundred-foot level."

"How do you happen to know so much about the matter?" we inquired.

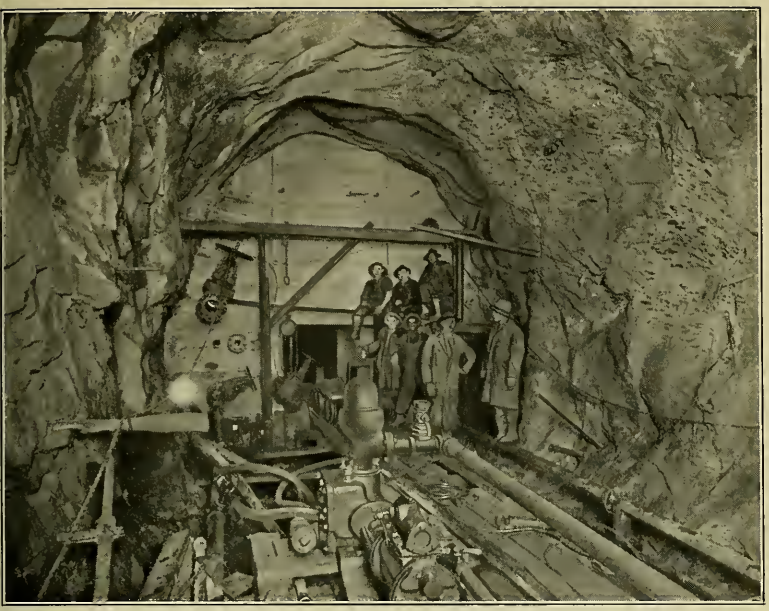
"Oh, I am just a taxpayer, but I like to know what I am paying for with my taxes; and then, too, I take a civic pride in New York's big undertakings."

"Jim, we've got to go up and see that work," said Bill.

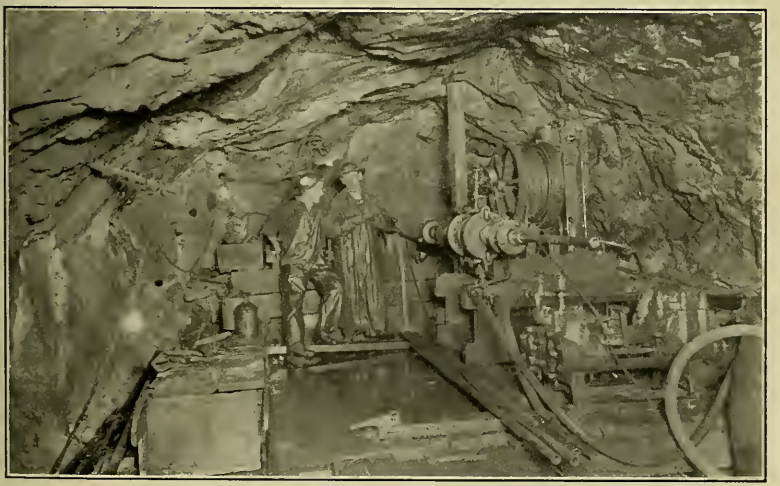
"There is a good deal to interest you right here, too," continued the stranger. "Do you know the tunnel at this shaft is two hundred and fifty feet below the surface? And it goes right down the Island of Manhattan at about that same depth, and then it goes under the East River, dipping down to a depth of over seven hundred and fifty feet, just so as to keep in solid rock all the way."

"But why don't they put pipes down?"

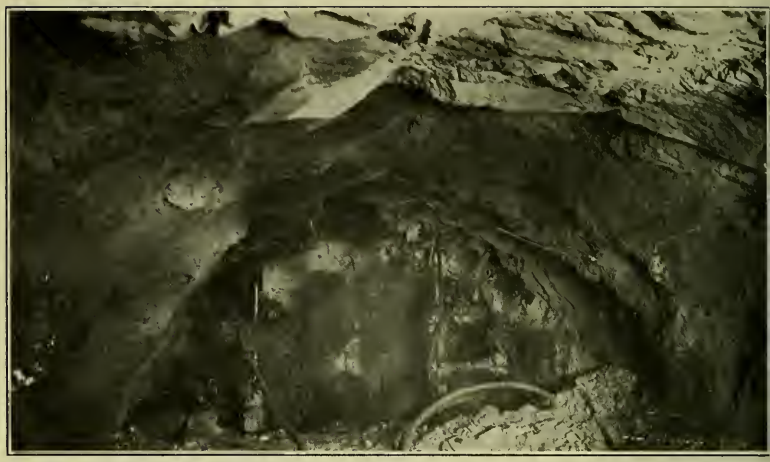
"There are lost of reasons. They would cost more. Two or three pipes would be necessary because a single pipe to carry all that water would be out of the question, and then



IN THE TUNNEL 1100 FEET BELOW THE HUDSON RIVER.



BORING WITH A DIAMOND DRILL IN THE HUDSON RIVER SIPHON.



DRILLS SET UP AT A TUNNEL HEADING.

"HOLED THROUGH" FROM ONE SHAFT TO ANOTHER.

there would be the expense of flexible joints, which would have to be strong enough to carry the pressure, and to keep the pipes from breaking under the drag of the tide. Oh, yes, pipes would involve constant care to keep them from breaking or rusting through. I don't believe you realize what an enormous pressure of water there will be in this rock tunnel. Why, in the down-town section, the pressure will be enough to send the water up to the top of a twenty-five-story building without pumping. In fact, the pumping stations around the city now will no longer be necessary."

We must have spent an hour or more with this chance acquaintance, discussing the wonderful work on this tremendous engineering undertaking. We got so excited over the matter that we started down-town at once to visit Mr. Price, and get a letter of introduction to the chief engineer of the aqueduct. We were most anxious to go up the Hudson and see for ourselves the work on the great siphon. We thought it would be quite a stunt to go down a thousand feet under ground.

When, a couple of days later, we stepped off a train at the little station of Storm King, we found the work there in progress even more remarkable than we had imagined it. The shafts at each side of the river had been sunk to their full depth, and the "headings" had been pushed so far that there was only about a hundred feet more of rock to cut through.

The trip down that shaft seemed never-ending, and when we looked up from the bottom, the opening at the top

showed as a tiny patch of light "no bigger than a quarter," as Bill described it.

"I suppose the atmosphere here is quite considerably denser than on the surface," said Bill, puckering up his lips to see whether he could whistle.

"Don't!" shouted the superintendent, leaping forward and clapping his hand over Bill's mouth.

"Wha—what's the matter?" gasped Bill, in astonishment.

"Simply this: our miners on this work are all southern Negroes, and a more superstitious lot you couldn't find anywhere. They have a strange notion that if any one whistles under ground, bad luck is sure to follow. More than once they've quit work because of some silly superstition. Why, they stampeded out of the tunnel a couple of weeks ago, merely because a lady visitor came down to see the work. That meant bad luck, sure, and nothing could induce them to go to work again until the next day."

After our previous whistling experience, we were inclined to think that this was another joke on us, but when we asked some other engineers about it, we were assured that it was a fact.

At the bottom of the shaft, there was an electric "dinky" (locomotive) and a couple of "muck" cars. We climbed into one of the cars, and, at a signal to the "dinky skinner" (locomotive engineer), we were off. The moisture in the tunnel made such a thick fog that we could not see anything but the faint glow of the electric lamps, strung at infrequent intervals along the roof. Once in a while we passed the

shadowy form of a workman, drawing back at the warning of our gong to let us pass. At first, all sounds were drowned out by the noise of our train, which echoed strangely in that long rock cavern, but gradually another sound rose above the din, a sound that grew louder until it became deafening. Then our train stopped, and we jumped out to watch the drill gang at work. The racket was of a throbbing nature most distressing to the ears, and very trying on the nerves. Altogether, there must have been half a dozen drills, all going at once, pounding their steels into the rock like a riveting-hammer, at the rate of about 400 blows per minute. Once I visited a boiler-shop, and thought that the noise there was about as distressing as any noise could be, but that was quiet compared to this racket. Under the rapid blows the rock under the steels was reduced to a fine powder, which, in the case of all holes which slanted downward, was washed out by streams of water.

Before we went down the shaft, the superintendent explained just how the holes were arranged (see Fig. 10). The upper half, or "heading" of the tunnel, was run about twenty yards in advance of the lower half, or "bench," so as to facilitate matters and let the two drill gangs work at the same time. It is comparatively easy to blast away the "bench," because the "shot" holes are drilled downward from the flat upper surface, and when the dynamite is set off it splits away the rock in slabs; but in the case of the "heading," a special arrangement of "shot" holes is neces-

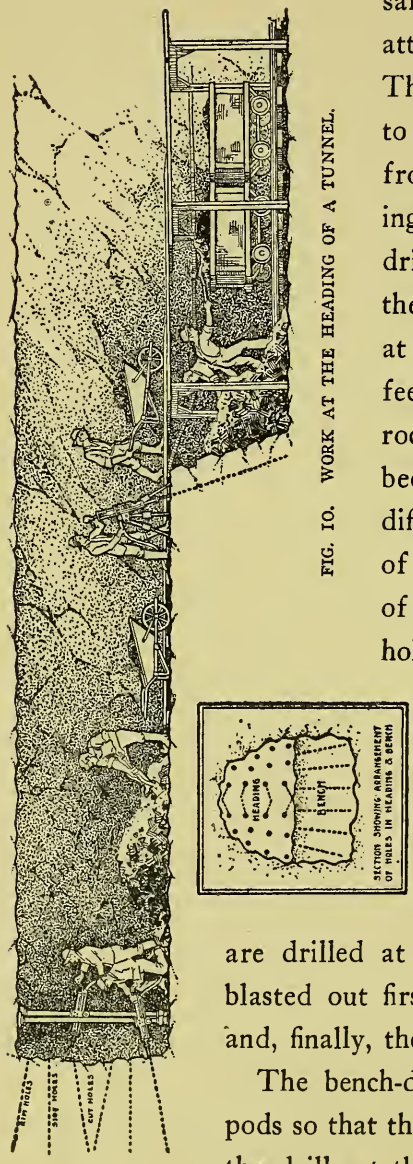


FIG. 10. WORK AT THE HEADING OF A TUNNEL.

sary, because the rock can be attacked only from the face. The first thing to be done is to remove a wedge, or "cut," from the center of the "heading"; two rows of holes are driven in at an angle so that they will meet, or nearly meet, at a depth of about eight feet back from the face of the rock. After this wedge has been blasted out it is not so difficult to split out the rest of the heading. At each side of the "cut" a row of "relief" holes is drilled, and finally a set of "liners" that slant outward to some extent, so that the rock will be shattered to the full diameter of the tunnel. Of course, all these holes are drilled at once, and then the cut is blasted out first, then the "relief" holes, and, finally, the "liners."

The bench-drills were mounted on tripods so that they could drill vertically, but the drills at the heading were carried on

two posts or columns that were tightly wedged between the bench and the rock roof overhead by means of jack-screws. There were three "engines" on each column, so mounted that they could be turned in any desired direction. We watched one of them starting a hole on a shelving piece of rock. The steel was pounding with short, quick strokes, trying to hammer out a seat for itself, while sparks were dancing around the drill point. After a while, when a sufficient hollow had been pounded in the rock, the steel began to strike with longer and longer blows, until it reached a full seven-inch stroke. The exhausts of the drills were coated with something white and glistening. One of the men scraped off a bit of the stuff and handed it to me. It was frost! I stared in astonishment! We couldn't, comfortably, do any talking down there, but when finally we got back to the surface, the superintendent explained it to us as follows:

"These drills are run by air compressed to one hundred pounds per square inch. When that air is compressed, up at the pumping station, it gets so hot that it blisters all the paint off the compressors, where they are not protected by water-jackets; in fact, it gets so hot that we cannot bring it to the full one hundred pounds at once, but have to compress it in two stages, and cool it off between stages. You know how it is with a bicycle pump, don't you? It gets so hot that you can scarcely bear your hand on the cylinder, just from the heat that is developed in compressing the air. Well, this compressed air we use has to be cooled, before

we bring it down into the tunnel, by passing it through radiators and water- or air-cooled cylinders. But if air gives off heat when it is compressed, very naturally it has to absorb heat again when it is expanding, so as to regain what it lost before. It absorbs so much heat out of its surroundings, that any moisture it contains is condensed, and settles as frost around the exhaust-port. In fact, if we don't watch carefully, it is likely to freeze the parts fast."

We went down the shaft again later, to watch the charging of the holes after the drilling was completed. The drill boss began first with his "cut" holes. The dynamite cartridges were about eight inches long and an inch and a half in diameter, wrapped in paper tubes. The man would take a stick of the dynamite, or "powder," as miners call all explosives, place it in the hole, and press it home with a wooden ramrod, so that the paper wrapper would burst open, and the soft, putty-like stuff would be mashed out to fill the hole completely. Other sticks of dynamite were then put in, each being rammed up against the preceding one. In one of the sticks he jabbed a wooden marlinespike, to make a hole for the detonating cap. After sticking the cap in place and fastening it with a half-hitch of the electric wires around the cartridge, he rammed it up against the rest of the dynamite, then put in a few more sticks, and finally closed the hole with a cartridge filled with sand. Extra heavy charges are always necessary to remove the "cut." About ten or a dozen sticks were used to each hole.

The wires to the detonating caps protruded from the holes, and the foreman connected them to a pair of line-wires that ran back to a bulkhead, or strong oaken shelter, about 300 feet away. When everything was ready, the men would hide behind this bulkhead while the boss did the "shooting" by closing an electric switch.

The superintendent thought it a little too dangerous for us to stay there, so we went all the way back to the shaft. As we were on our way, there was a sudden crash that sounded like a pistol shot directly overhead. Bill and I both jumped a yard. We thought the dynamite had exploded. The superintendent only laughed at us.

"That is nothing but the flaking of a piece of rock overhead," he explained; "you must remember that we are going through rock that was made ages ago, and is under enormous pressure. When we cut a big hole through rock of this kind, the pressure is relieved to some extent, and the rock actually expands into the bore. This movement results in flaking off pieces now and then. We have had flakes weighing all the way from a few ounces to a couple of hundred pounds. When the first pieces flaked off, the workmen were badly frightened, and all stampeded. As I told you before, they are a very superstitious lot. After a while, the reports became so frequent and the fall of stones so dangerous, that we had to do something to protect the men. You see, we have a wooden sheathing just under the roof of the rock to catch these unexpected missiles. It seems odd, doesn't it, that the power back of those missiles

was put there millions of years ago, when the rock was hot and began cooling and contracting."

By the time he finished talking, we reached the shaft and were carried up to the surface. Suddenly, a boom and a dull roar told us that the powder had done its job down there deep in the rock. We were anxious to see what the shot had accomplished, but we were not permitted to go in again.

"Don't you know that the fumes of 'shooting' are poisonous?" asked the superintendent.

"But how about the men?" I asked. "Won't it kill them, too?"

"We pump air in there to blow the fumes out. In about five minutes, they can go back and charge the "relief" holes. But if you went in there, it would give you an awful headache. The men get used to it, but in time even they are liable to be overcome. By the way, you ought to see how they store dynamite in New York. It is interesting. The Bureau of Combustibles will not let any one keep a large quantity of explosives in the city, particularly in congested parts, but at each shaft they use from seven to eight hundred pounds of powder per day, so they have underground magazines hewn out of solid rock. When you go back to town, call on my friend Douglas, at Shaft 13, and he will show you one of the magazines and how it is constructed."

A ROOF OF STEEL WHERE THE ROCK IS SHAKY.

A SUBTERRANEAN STREAM THAT KEEPS THE PUMPS BUSY.

RAMMING THE POWDER INTO THE SHOT HOLES.

ENTRANCE TO THE DYNAMITE CHAMBER.

CHAPTER XV.

CAGING DYNAMITE.

THE shaft of which Mr. Douglas was the superintendent was the very one we had first seen in the park, and now, with Mr. Douglas as our guide, we stepped into the cage that we had watched from the bridge, and plunged down 250 feet below the surface. At one side of the tunnel, about one hundred feet from the shaft, there was a heavy mass of concrete with a low doorway in it. The opening was closed by a light, outer door, consisting of a wooden frame covered with chicken wire, alongside which a man stood on guard. Back of this there was a very massive door that was then ajar, at an angle of forty-five degrees; a pin in the floor kept it from opening any more than that. Mr. Douglas led us past these doors into a large passageway cut out of the solid rock. A few yards from the door the passageway turned abruptly at right angles to the left; then a few yards farther it made another turn, but to the right; a few paces more brought us to a large chamber that extended to the left again. At each turn of the passageway, there was a pocket cut in the rock in the opposite direction from the turn. In the chamber, which measured about sixteen feet high and over thirty feet long by twenty-six feet wide, there were fifteen or twenty cases of dynamite,

over which was a timber roof as a guard against any pieces of stone that might be dislodged from the rock overhead and fall on the powder.

"Did you ever smell dynamite?" said Mr. Douglas, picking up a stick and holding it under my nose. I jumped back in alarm. "Oh, it won't hurt you!" he said reassuringly, "but if you smell of that sickish stuff awhile, it will give you a headache. Now if this powder should go off ——" Mr. Douglas paused.

"Yes?" I said nervously.

"Oh, we do not expect such a thing ever to happen, but you never can quite tell about dynamite. If it isn't perfectly fresh, it might go off if you sneezed upon it. You know dynamite is made of nitroglycerin and gelatin. The gelatin holds the nitroglycerin as a sponge holds water. When it is exposed to extremes of heat and cold and moisture, the glycerin separates from the gelatin, and collects in little bubbles that are extremely sensitive and will go off with scarcely any provocation.

"I remember once," continued Mr. Douglas, "when I was a young lad, my brother and I were anxious to try our hand at shooting. Father was a contractor, and was doing a job out in Oregon, and we boys worked there, with the men. Well, as I was saying, one day when the men were off at lunch, we went to the dynamite house and got out a case of dynamite. The heading was all ready for the powder, and we thought we could shoot it just as well as any one else. I carried the case of dynamite over to the shaft

while my brother was getting the fuses. When I got to the shaft, the bucket was up at the top, near enough, as I thought, for me to reach over and put the case of dynamite on it, even though it did weigh fifty pounds. However, as I leaned over the edge of the shaft, I kicked against a pick or a shovel that lay in my way, and this hit the bucket and pushed it out of my reach; but I had leaned so far that it was impossible for me to regain my equilibrium, and I had the alternative of dropping the fifty pounds of dynamite, or falling down the shaft with it. It didn't take me a second to make my choice, and then, as the case shot down the shaft, I ran. Yes, I did some real running. My brother saw me running, took one glance at my face, and then he also ran some. So did the engineer of the hoisting-engine. The shaft wasn't more than one hundred and eighty feet deep, but we ran long enough for that dynamite to have dropped ten times as far. Then we stopped to collect our wits. Well, sir, that powder never went off! When my father heard about it the next day, he made it the text of a sermon. All the men were lined up to hear his speech, and it certainly made an impression upon me. 'I want you to understand,' says he, 'that dynamite is dangerous stuff to handle, even though a case of it did fall one hundred and eighty feet without exploding. It is dangerous stuff, I tell you, and should always be treated with respect. After that incident of yesterday, you may get the notion that all this talk about the danger of dynamite is mere nonsense, but, let me tell you, that dynamite was perfectly fresh. Two

or three months from now that very same powder will be so touchy that you cannot drop a pebble on it without setting it off. The only way to handle dynamite safely is to treat it with due respect always, because you never can tell in just what condition it is.'

"Well, as I was saying, if this powder here should happen to go off," resumed Mr. Douglas, with exasperating deliberation, "the explosion wave would smash into that pocket at the other end of the chamber, where it would come up against a wall of solid rock; then it would have to go off at right angles down the passage, where it would find itself in another pocket; again it would have to dart at right angles, only to dash into the third pocket, and by the time it found its way out to the door, it would have lost much of its energy, and it would hit the door with a gentle shove of something like five hundred and forty tons, or about one million pounds. It sounds like a long story, but it would all happen like that," and he snapped his fingers. "The door would slam shut, and the poisonous fumes would be trapped inside without any way of escaping. You can get some idea of the energy of dynamite when I tell you that the gases will exert a steady pressure of one hundred and fifty pounds per square inch on every square inch of the chamber in passage until they cool down. In other words, the powder which in the solid state occupied less than fifteen cubic feet, will be turned into a compressed gas occupying twenty thousand cubic feet. When the gases cool down sufficiently, we can force them out with com-

pressed air. So you see we can let the powder explode without injuring anybody except the magazine tender. There wouldn't be much left of him, I fear. But the men outside would not be in danger, and the busy city two hundred and fifty feet above would scarcely know that anything had happened."

"But," said Bill, who had been by no means convinced, "I thought nothing could stand up against such a quantity of dynamite. I don't see how any door can hold it."

"Do you know," said Mr. Douglas, "there is more energy in a pound of gasolene than in a pound of dynamite? But here is the difference, gasolene combustion is comparatively slow, while the chief value of dynamite is the suddenness of its explosion. It is chiefly that first explosion wave that we must guard against, and so we make it dash itself against the rock walls until it is pretty well spent. This door here" (we had come to the end of the passageway by this time) "is made to stand twice the pressure that we estimate it will be subjected to. See, it is built of heavy steel I-beams, with oak timbers twelve inches square between them; and then the doorway is set in an enormous mass of concrete. Oh, no, it could not possibly give way."

"But have you tried it?" asked Bill.

"Oh, yes, we exploded half a dozen sticks just around the first bend, and it slammed the door shut, nicely, and the drain here—but I haven't shown you that yet." There was a gutter running down the center of the rock floor to the passage to carry off any moisture that might seep in.

"We have to run that drain through to the outside, and that ventilating pipe you see overhead also has to have some connection with the outside, and so we have an opening under that plate in the floor and a tapered plug hanging on a guide rod just in front of the opening. Well, as I was saying, when the powder went off, it drove that plug into the drain so hard that we had to use a hydraulic jack to force it out."

"But," persisted Bill, "you have never exploded a full charge of one thousand pounds, have you?"

Mr. Douglas laughed. "Look here, young man, you would make a pretty good lawyer. No, we have never tried it here, but in Europe, where the idea originated, because they have to do so much mining right under large towns, fully as much powder as that was set off once without the slightest damage to anything outside. There was a small car in front of the door of the magazine, but it was not in the least affected by the explosion."

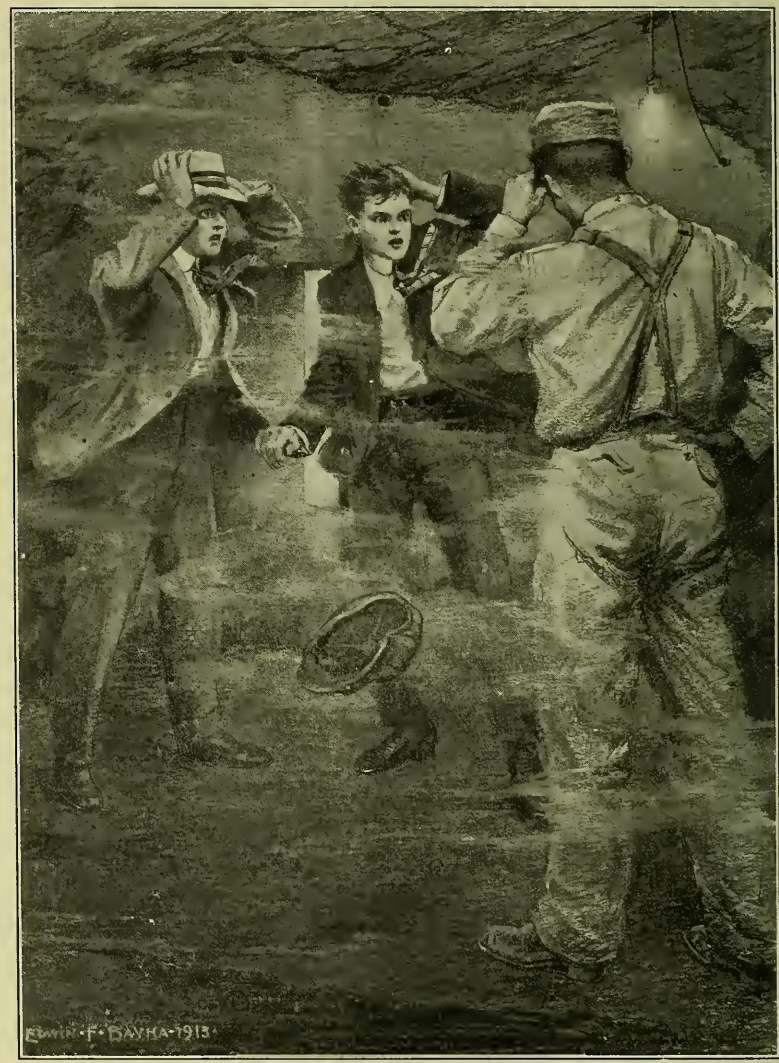
It was wonderful, and I was glad we had seen it, but all the same it was a decided relief to step out of that deadly chamber.

Just as we emerged from the magazine, the lights in the tunnel began to wink slowly once, twice, three times.

"Hello!" exclaimed Mr. Douglas, "that is the signal to hunt for cover. They are going to shoot the heading in half a minute. We had better step into the magazine to be sure that no flying pieces of rock hit us."

"The magazine!" I cried in astonishment. Of all places

THE DYNAMITE CHAMBER. NOTE THE COVERED SHELVES ON WHICH THE POWDER IS STORED.



"ANOTHER BLAST CAME OUT OF THE MAGAZINE BEHIND ME."—See page 143.

on earth that was the last I would ever seek as a refuge from a blast, but I was hustled into the place before I had time to make any protest.

When we got inside I expected them to shut the door. In fact, Bill and I both tried to shut the door because we knew there was no time to lose, as Mr. Douglas had said that the shot would be fired in half a minute after the signal. But he motioned us to desist. "We never close that door. That counterweight is put there for the very purpose of holding the door open," he said, pointing to a rope that ran from the top of the door over a pulley on the wall, and was attached to a heavy iron weight.

Imagine our feelings. Forced to seek shelter in a cave charged with dynamite, a thousand pounds of it! What was to prevent the shock from setting it off? and then where would we be? A thousand thoughts chased through my brain in the brief moment before the explosion came.

It is a curious thing about blasting, that the sound travels through the rock much faster than it does through the air, and so there is always a warning crack an instant before the crash of the air wave reaches the ear. Just before the warning sound came, the superintendent shouted something that I didn't catch; but I saw him grab at his hat, and I followed his example, not a moment too soon. The next instant, I was engulfed in a terrific roar of noise and a rush of wind that all but swept me over on my back. But as I reeled, another blast came out of the magazine behind me, and pitched me forward. I thought for the moment

that the dynamite had been exploded by the concussion, and I made for the door. I was conscious that the door actually swayed forward a bit, and then settled back under the pull of the counterweight. Then I saw the superintendent laughing, but he was laughing at Bill, and not at me, thank Heaven. Bill had not been quick enough to grab his hat. The explosion wave had carried it off his head, and sent it sailing around the zigzag passageway of the magazine, but—and that was what the superintendent was laughing at—the *return* wave coming out of the magazine *brought the cap sailing back and dropped it at his feet!*

"That is the beauty of this magazine," laughed the superintendent, picking up the dirty, bedraggled cap and handing it to Bill. "If you had been out in the tunnel, your cap would have sailed off, Heaven knows where, and it might have taken you all day to find it. But here in the magazine it is sure to come back on the return wave. Even though it may be a bit dirty, you will always get your headgear back again. But we better get out of this before the smoke gets too thick." Already the smell of the fumes was quite noticeable, as they were being driven out by the air that was being pumped to the heading.

It is a curious fact that when one is going through great dangers, whether real or imaginary, the mind is not infrequently impressed with minor details which come back very vividly to a person when he has time to think over his experiences. While I was imagining all the horrors of death in the magazine, my eyes took in a very queer phenom-

enon. It all came back to me as we were going up in the cage to the surface. When the first explosion wave struck us, it had seemed as if I could actually see the air wave rush into the passageway like a foggy cloud, and dash into the still air about me. But the strangest part was that, as it appeared to hit the still air, drops of water seemed to form under the electric lamp where I was standing, and fall like a scattering rain to the ground.

When I mentioned it to the superintendent, he did not think I was crazy, but told me that my fleeting impression was a fact.

"Yes," he said, "on a damp day such as this, you can actually see water squeezed out of the moist air if you happen to be standing in a very good light."

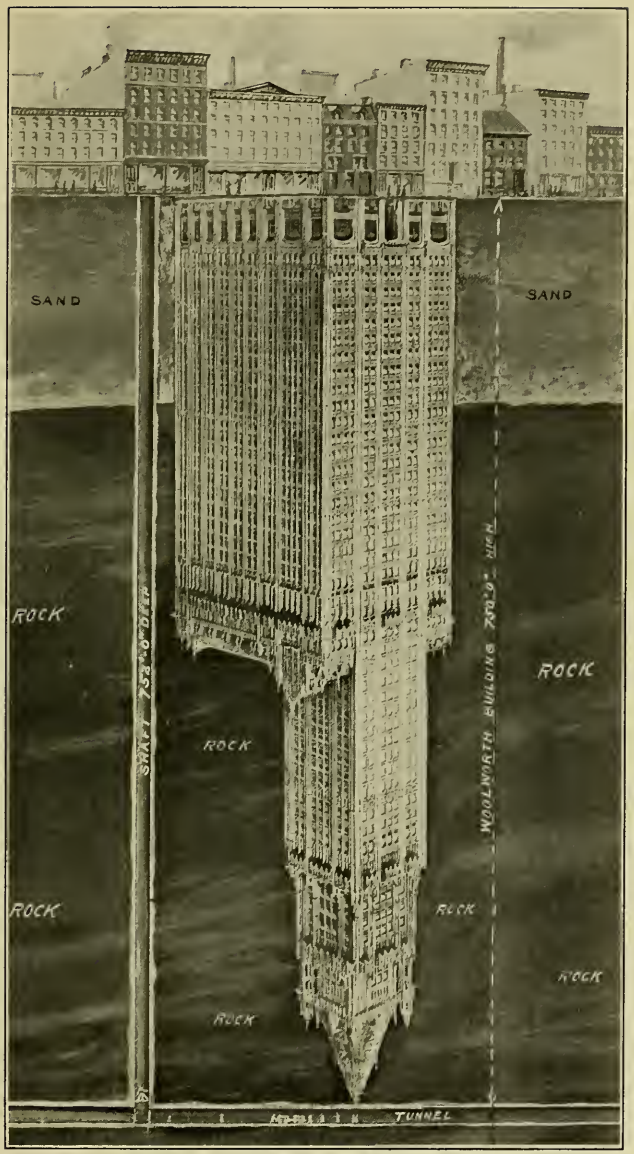
CHAPTER XVI.

A LIFE-SAVING FALL.

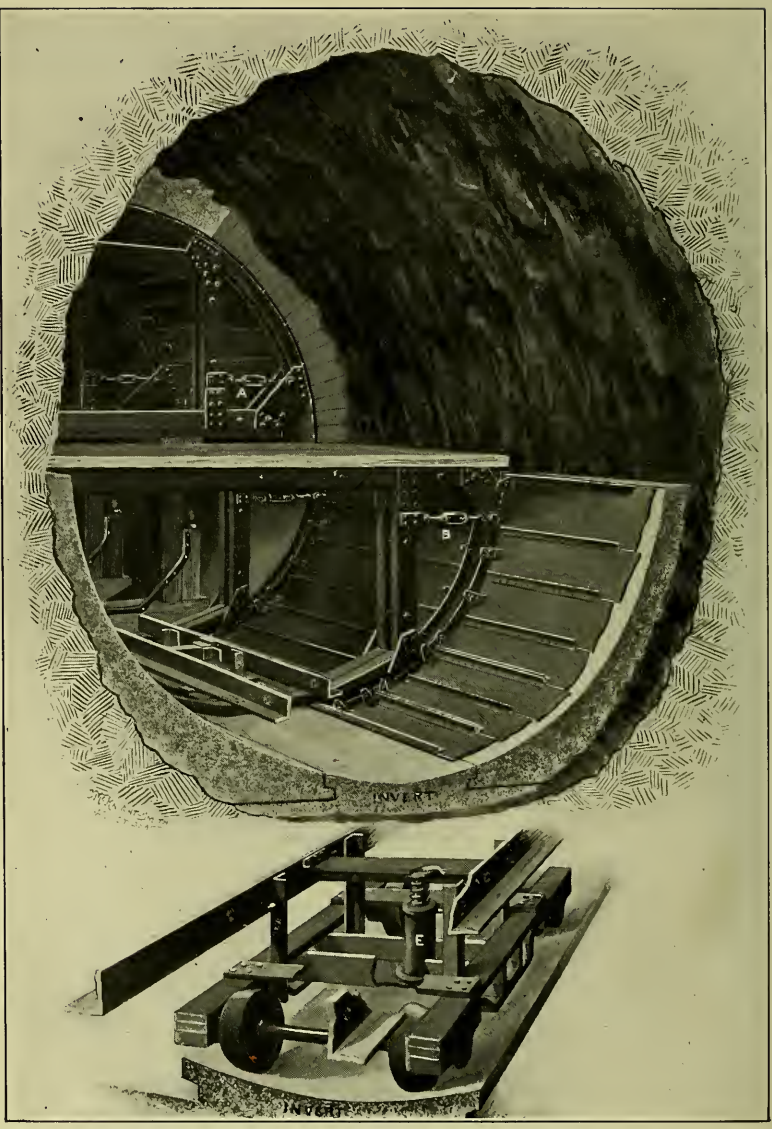
Hanging in Mr. Douglass' office were some blue prints that showed the course of the aqueduct through the heart of Manhattan and under the East River to Brooklyn. One was a sectional view showing the depth of the tunnel under the surface. This puzzled us not a little because the depth seemed out of all proportion to the length of the tunnel. For instance, the East River looked like a very narrow stream, not half as wide as the depth of the tunnel passing under.

"The East River must surely be half a mile wide," remarked Bill, and if so it looks as if the aqueduct were a mile and a half under ground. That can't be right, can it?"

"Don't you see the scales on the blue print?" replied Mr. Douglass. "There are two of them, one for length, 2,000 feet to the inch, and the other for depth, 100 feet to the inch. If the length were drawn on the same scale as the depth there would not be room enough on this wall for the map. It would be about 30 feet long. On the other hand, if the depth were drawn on the same scale as the length it would be impossible to tell slight variations. For instance, a drop of 10 feet would be actually but 1/200 of an inch, which wouldn't show at all. Engineers always exaggerate



THE HIGHEST BUILDING IN NEW YORK AND THE DEEPEST SHAFT.



COLLAPSIBLE FORMS FOR CONCRETING THE AQUEDUCT TUNNEL.

depths at the expense of lengths so that they will show to good advantage."

"Do they really?" asked Bill in astonishment. "I thought engineers never exaggerated anything, but always stuck to the honest facts."

"You can hardly call it dishonest when the scale is always there, right before you, on the map."

"There is something I can't understand," I broke in. "The tunnel seems to be deepest under Manhattan, instead of under the river. It actually rises on the way under the river."

"Yes, and there is a geological story connected with that. Ages ago, so geologists tell us, the East River lay over what is now the 'East Side' of Manhattan, and it had a very deep channel, as can be seen by the outline of the rock over here," pointing to the right of the East River. "Then the Ice Age came on. Great glaciers slowly crept down out of the north and invaded this region, working havoc with the landscape. The old bed of the river was obliterated. Enormous masses of earth and rock scraped up by the advancing ice filled it up and the East River had to make a new channel for itself on a ledge of rock to the eastward. If we had only the present bed to deal with, the tunnel could safely be run at a 400-foot depth, but it is the old river bed that makes us go down 750 feet below the surface.

"By the way, I picked this up in a magazine the other day," Mr. Douglass continued, turning to a scrap book. "It gives you some idea of the depth of the tunnel at this point."

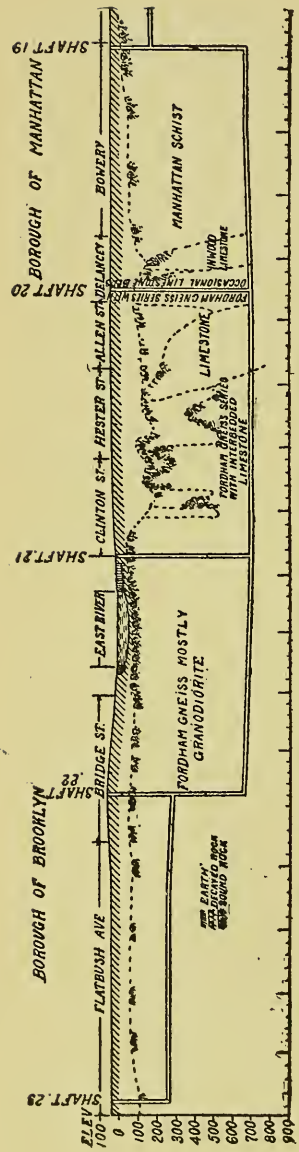


FIG. 11. HOW THE AQUEDUCT RUNS UNDER THE PREGLACIAL BED OF THE EAST RIVER.

The picture showed a tall office building inverted and built from the ground level downward.

"I suppose you recognize that as the tallest office building in the world, 750 feet high. That happens to be the depth of the tunnel under the street level at shaft 20. It is quite a coincidence that you can go down as far as you can go up in this city."

"Say, we must go down that shaft, Bill," I exclaimed. "Can we, Mr. Douglass?"

"It's not in our section of the work," he replied, "but I am sure you will not have any trouble. Jack Patterson, over at shaft 20, is a fine chap, and he'll fix it up for you."

"How do you get there?" asked Bill.

Mr. Douglass pointed to the map showing the course of the tunnel and told us what cars we should take.

"Is that the course of the aqueduct?" I asked, pointing

to the heavy line that zigzagged across the city. "Why does it take so many turns?"

"It has to follow the streets, you know, so as to keep off private property."

"Private property; 750 feet underground!"

"Why yes. If you own a lot you own it down to the center of the earth. If we should run across your slice of the earth, a half a mile or a hundred miles under ground, you could sue us for trespassing. Some day people may stop building from the ground up and start from the street level down; then they would not like to run into the aqueduct, even though it were a seventh of a mile under the surface.

"By the way, how would you like to see some of our concreting work. You know this hole through the rock is to be lined with a thick layer of concrete so as to make a smooth-surfaced concrete tube for the water to run through. We are putting in the lining in a new way. I think you would be interested to see it."

"Certainly, we should."

"A little further downtown," explained Mr. Douglass, as we proceeded out of the office to the street car, "we have 'holed' through from one shaft to the adjacent shaft on each side, and there we have set up our concreting forms."

At the shaft to which Mr. Douglass lead us, there was a rather elaborate concreting plant. It was situated in a city square and was enclosed by a board fence. Projecting far above the fence was a wooden tower that looked something like a grain elevator. Near the top cement was stored and

below side by side were two main storage bins, one for sand and the other for gravel. Right in front of these storage bins were two smaller "service" bins and below them was the concrete mixing machine. Figure 12 shows the arrange-

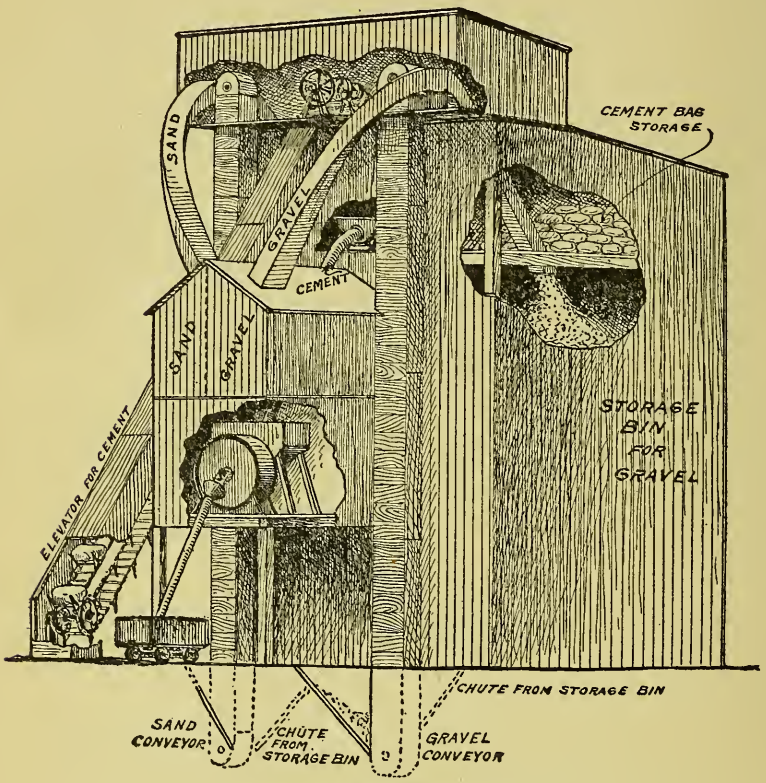


FIG. 12. THE CONCRETING PLANT.

ment, also the elevator for carrying the cement bags to the top of the tower and the conveyers for the sand and gravel. By moving a lever the sand or gravel could be turned either into the main storage bin, or into the smaller service bin.

When the material ran low in the service bin gates were opened at the bottom of the storage bin and the conveyor carried up the material to replenish the service supply. From the service bins the sand and gravel were led down to a concrete mixing machine where they were mixed with proper proportions of cement and water, after which the material was delivered to cars which carried the liquid concrete down in the elevator cages.

We went down in an empty cage for fear of being splashed with concrete. Then we scrambled over the ties of the "dinkey" railroad to the concreting forms.

Along the bottom of the tunnel was laid a segment of concrete lining, which Mr. Douglass called the "invert." The drawing opposite page 147 shows the form of the invert. It was put in before the concreting forms were erected and provided a roadway on which the forms traveled. The forms were two semi-cylindrical sections of steel plating, one for the upper half or "arch" of the tunnel, and the other for the lower half or "side walls." (See Figs. 13 to 15.) The two parts were set one in advance of the other. A platform, providing a floor for the arch form adjoined a second platform which served as a roof for the side wall form.

At the time of our visit the men were working on the upper form, and the incline led up to the platform. Up this the cars laden with wet concrete were hauled. Mr. Douglass explained that when they were working on the lower half the incline could be lifted up, as shown by dotted lines in Figure 15, and the cars passed under it to the side

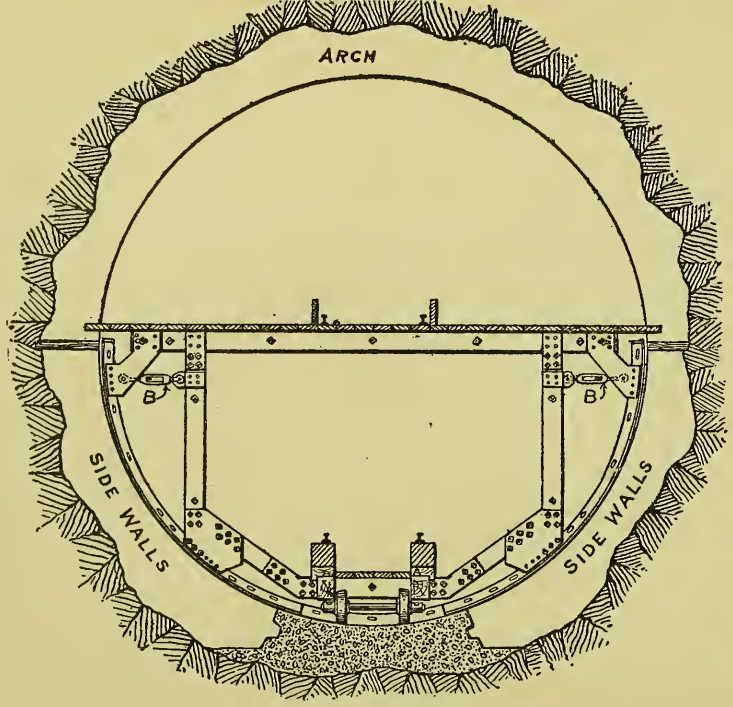


FIG. 13. CROSS SECTION OF THE LOWER FORM.

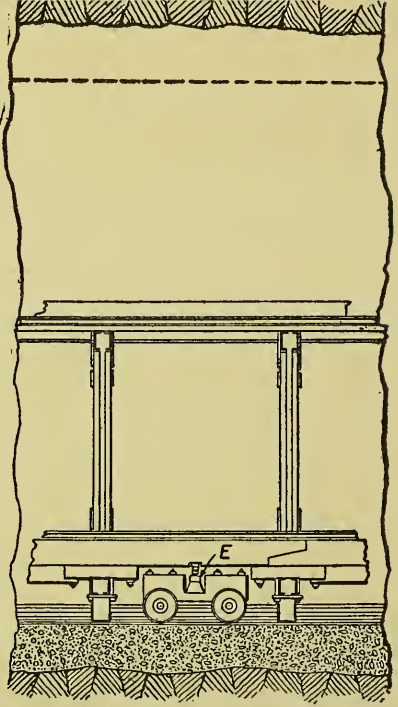
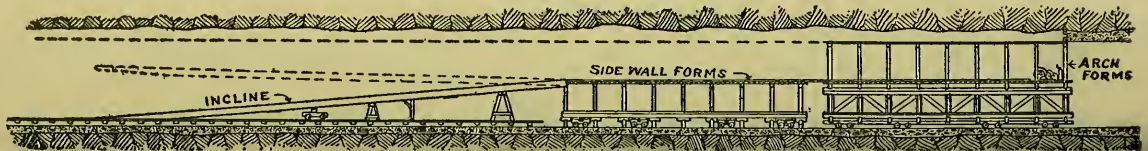


FIG. 14. SECTIONAL SIDE VIEW OF THE FORM.



wall form. Filling the lower form was a simple matter. The concrete was merely poured between the steel shell and the rock until it filled the space up to the "spring line," or middle line of the tunnel. To keep the stuff from pouring out at the end of the form before it set, small pieces of board were temporarily nailed against the edge of the form and fitted as neatly as possible against the rock. The lower half of the tunnel was concreted in advance of the upper half, so that the top of the side walls would provide a footing for the concrete poured into the arch section.

Concreting the arch was a more difficult process. A section of plating was removed from the top of the form and the concrete was shoveled in through the opening. It was necessary to use stiffer concrete for this work than that used for the side walls. Men had to climb in between the shell of the form and the rock to shovel the concrete into all the crevices. When the space was nearly all filled the section of plating was restored to its position and the concrete was shoveled in from the end. At the very top of the tunnel pipes were left embedded in the concrete, through which, later, "grout" or a mixture of clear cement and water could be forced under high pressure to fill up every crack and crevice, making the lining perfectly sound.

"After this concrete hardens we are going to slide the forms forward."

"What, those heavy things?" I asked in astonishment.

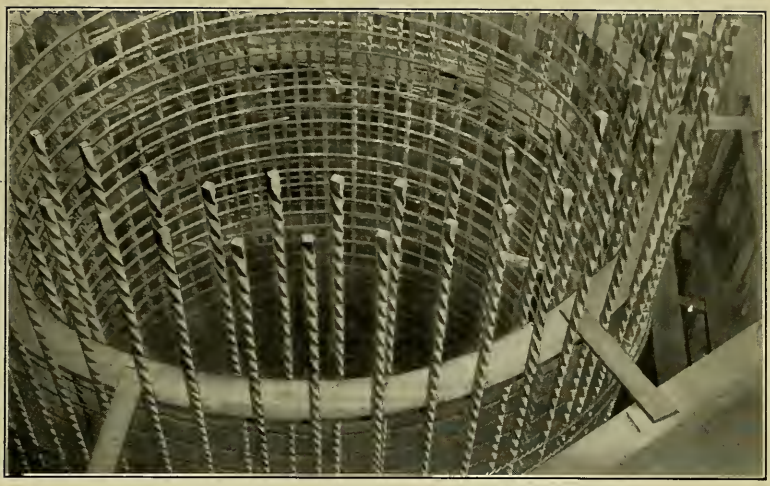
"Yes, they are mounted on wheels, don't you see?" and Mr. Douglass pointed to a pair of wide rimmed wheels

tapered to fit the invert. "First we collapse the forms"—and he went on to explain how by screwing up certain turnbuckles (B, Fig. 13) the shells could be drawn inward. Figure 13 shows the side wall form collapsed so that the upper edges are drawn away sightly from the finished wall. When this was done the form was raised on the trucks by screwing up the jacks E (Fig. 14).

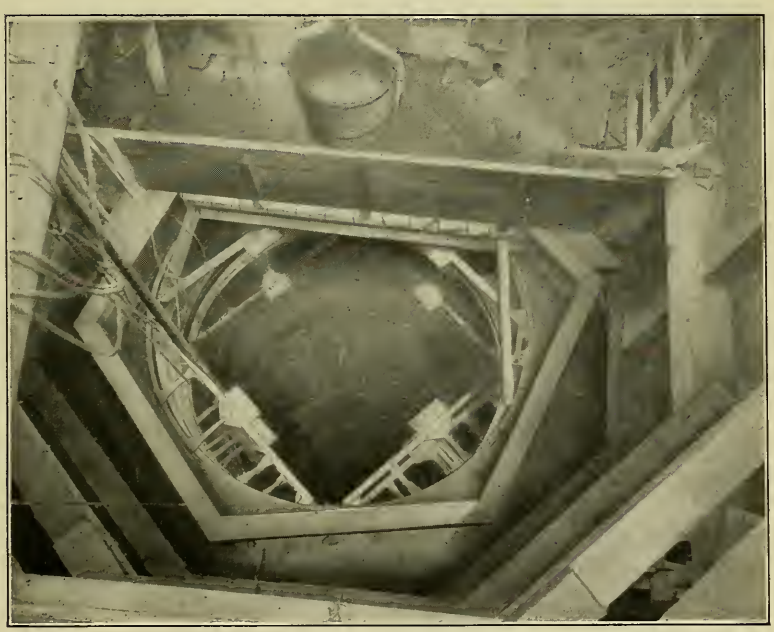
The arch form was lowered by screwing up the turnbuckles shown at A in the drawing facing page 147, and operating jacks to lower the form until it cleared the arch. Thus freed from the concrete, the forms could be moved to a new position so that the arch form would overlie the side walls just completed.

Many a visit we paid to the aqueduct, all along the line. There was a great deal of sameness about what we saw and it would hardly be worth while to recount all our experiences. But there were two events worthy of note, one of which happened in the deep shaft, of which Jack Patterson was the Superintendent. He took us around himself.

While we were waiting at the shaft, a cage came up bringing a man who had been hurt. I could see that his cheek was badly gashed and he looked rather weak. A companion conducted him to the doctor's office. Then we stepped into the cage and went swiftly down to the bottom. Our trip down the shaft and into the tunnel, which had not proceeded very far at that time, developed nothing very startling. We had been more than 750 feet underground in the Hudson siphon, but we wanted to be able to tell

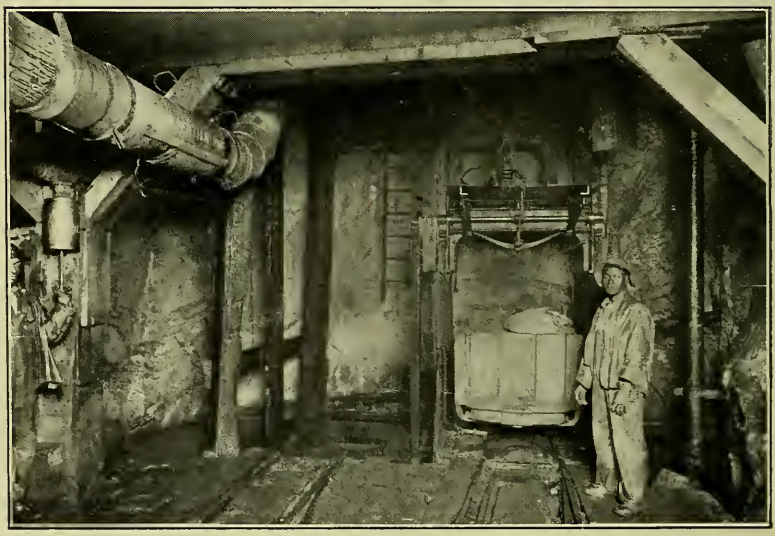


REINFORCEMENT FOR A CAISSON AT ONE OF THE SHAFTS.



LOOKING DOWN A DEEP AQUEDUCT SHAFT.

SECTION OF THE TUNNEL WITH SIDE WALLS CONCRETED.



THE CAGE AT THE BOTTOM OF A SHAFT.

people that we had been as far *under* New York streets as *above* them. When we returned to the shaft a cage was just coming down with two men in it, facing our way. As they stepped off one of them, who was the foreman of the drill gang, turned, casually, and looked behind him. Then he started, in alarm, and shouted "Where's Tony?"

"Who's Tony?" asked Mr. Patterson running up to see what was the matter.

"Why, the fellow that was just up to see the doctor. He was in the cage when we started down. Must have fallen off," and he hastily signalled to have the cage raised, expecting to find the mangled body of the man under it.

But there was no sign of Tony there.

"Who was the chap on top of the cage?" inquired Bill.

"Hey?" The Superintendent was getting excited.

"Why, I thought I saw a man up there fixing the chains or something."

Down came the cage in response to a frantic signal, and there sure enough huddled up on the covers that serve to protect men in the cage from articles that might drop down the shaft, lay Tony with his arm hooked around the hoisting cable.

"Say, am I drunk or dreaming?" exclaimed the foreman holding his head. "That fellow was in the cage when we started down, wasn't he, Mike?" appealing to the man who had come down with him.

"Sure, Oi saw him there, whin we wuz half way down. The Divil is in this," shaking his head.

Tony, limp with fright, was helped down and put through a cross-examination, but it was difficult to get a connected story from him, as he could speak but little English. Finally we made out that he had been standing close to the edge at the opposite side of the cage and, weakened by his injuries, had fainted when the cage was about half way down the shaft. That was all he knew until he discovered himself on top of the cage clinging to the chain. The only possible explanation was that he had fallen out, struck against the side of the shaft and bounced back again. In the meantime the cage had moved on so that he landed on top. He must have seized the cables instinctively and clung there. The shaft was full of braces and timbering which he must very narrowly have escaped striking. So miraculous was the occurrence that Mike continued to shake his head and walked off muttering, "The Divil wuz in ut; the Divil wuz in ut."

"Well, if the Evil One is around here," laughed the Superintendent, "we had better hurry out. Why don't you go over to shaft 21 and see the concreting there?"

"Oh, we saw the concreting in the tunnel at shaft 14," I answered.

"But this is different," Mr. Patterson explained. "There they are concreting a horizontal tunnel, while at 21 it is a vertical shaft that they are concreting."

"We'll have to see it then." I said. "Many thanks for the tip."

When we arrived at shaft 21 something had happened which might have been a very serious accident had it not

been for the presence of mind of one of the men. We found that the concreting was completed at the shaft and they were just removing the steel forms. The bottom of the shaft had been allowed to fill with water to a depth of about 25 feet. On a big platform several feet above the water a number of men were at work taking out the bolts that held the forms together and preparing them to be removed. The platform on which they were working was ring-shaped, leaving a large opening in the center.

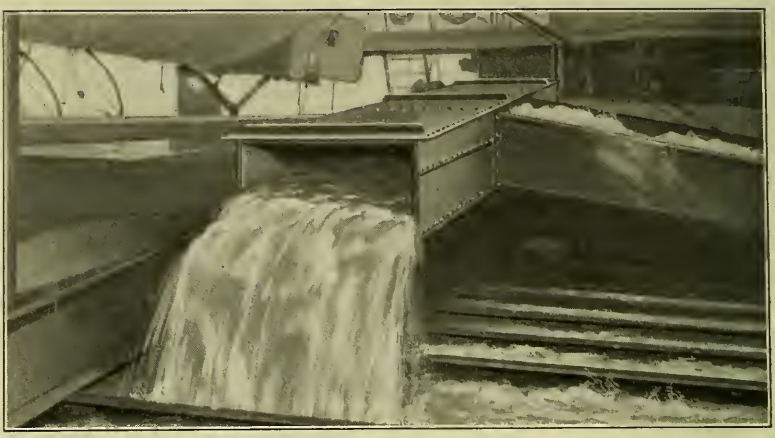
About 30 feet above this platform, working on a very narrow scaffolding, was a man whose task it was to attach the form sections to a hoisting cable and to pry the sections away from the concrete so that they could be hauled up. He was working with an 8-pound hammer in one hand and a heavy iron bar in the other. As he attempted to pry a section loose, it gave suddenly and he lost his balance. Had he dropped his tools he could have seized a cable that was hanging from the tackle and saved himself from falling; but it occurred to him, like a flash, that if he dropped the 8-pound hammer among the men 30 feet below him it would mean certain death to one or more of them. So, with rare presence of mind he clung to his tools, and as he reeled backward, gave a jump that dropped him through the opening in the lower scaffold and let him plunge 35 feet down into the black water below. Here he floundered around in the darkness until the men threw him a line and hauled him up.

We were so thrilled with the story that we insisted on

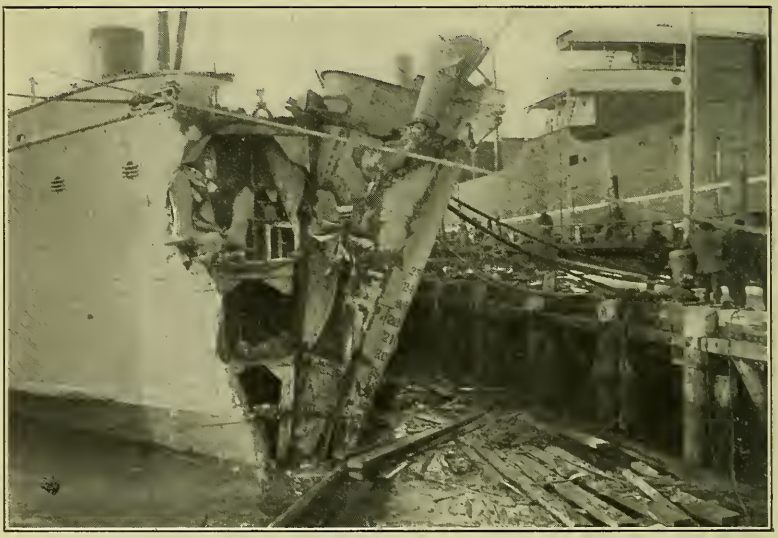
seeing the man and getting his version of it. But the fellow would not talk at all.

"Such things happen every day," he said. "I didn't do nothin' wonderful. You'd have done the same thing yourself."

DRIVING AN AQUEDUCT SHAFT. NOTE THE PNEUMATIC DRILLS MOUNTED ON TRIPODS.



WATER AND SAND FILLING THE BINS OF THE SUCTION DREDGE.



BOW OF A DREDGE AFTER COLLISION WITH A LINER.

CHAPTER XVII.

BOATS THAT DEVOUR MUD.

BILL and I made a wonderful discovery one day. We found in process of construction, right at New York's front door, a great ship-canal, an enormous excavation one-third the size of the Panama Canal, but because the canal was submerged under the waters of New York Bay, it came in for very little attention on the part of the public. Even those who had heard of the Ambrose Channel had not the slightest idea of its great size.

We met one of the engineers who was in charge of that work at that memorable luncheon with Mr. Price. He invited us down to see how the dredging was being done.

"A tug goes down to the dredges every Wednesday," he said, "to carry mail and supplies, and if you will call at my office on any Wednesday before 10 o'clock, I will give you a pass on the tug."

The invitation slipped my mind entirely, until one hot August morning, when there was not a breath of air stirring, and the heat of the city set us to planning a sea trip of some sort.

"How about that Ambrose Channel trip?" I suggested. "This happens to be a Wednesday."

"By George! I had forgotten all about that," answered

Bill. "However, I am not hankering after a dirty job like that."

"But we promised Mr. Barlow we would come," I reminded him, "and it would be rather shabby of us not to pay attention to his invitation."

"Well, if it has got to be done, this is as good a time as any, I suppose. At any rate it will be cooler than anything we can do in the city."

"He seemed to think we would find it rather interesting," I remarked.

"Judging by what I have seen of dredging, there is not so very much to it, only a big clam shell bucket that scoops up vile-smelling black mud and dumps it into a scow alongside. I guess we had better put on our old clothes for this job. We'll have to hurry, too, if we are to get there before ten o'clock."

The clock was just striking ten as we rushed into the Army Building on Whitehall Street and asked, breathlessly to be shown up to Mr. Barlow's office. We must have looked like tramps in our shabby old duds, our faces red as a beet, and the perspiration streaming from every pore.

"Are we too late?" gasped Bill, as we burst into the room.

"Eh? How's that?" exclaimed Mr. Barlow, in bewilderment, peering at us over his glasses.

"Excuse me," stammered Bill, "you've probably forgotten us. We were introduced to you by Mr. Price, the engineer, some time ago, and you promised to let us see the

Ambrose Channel work any Wednesday, if we got here before ten o'clock. It has just struck ten, and I'm afraid we are late."

"Well, well, so you're the two boys I met. I must confess I did not recognize you."

"We do look rather mussed up," I explained, "we have our old clothes on, so we won't be afraid of the mud on the scows."

Mr. Barlow leaned back in his chair and laughed heartily, although I didn't see why just then. "Ha, ha, ha! Prepared for the worst, are you? Well! well! that's a good one! I never knew boys were so careful of their clothes. I guess you are not too late." He sent a boy downstairs to see whether Captain Wheeler had left the building yet. He was still chuckling to himself as he dictated a letter of introduction to the engineer on board the dredge.

Fortunately for us, Captain Wheeler had not gone yet and inside of ten minutes we had our letter of introduction and were bound for Pier 12, where the tug was moored.

Neither of us had ever before taken a trip in a tug boat, and so we found our excursion down the bay exceedingly interesting. We had so many questions to ask about navigation, signals, light buoys, whistling buoys, bell buoys, etc., that we must have nearly pestered the captain to death. Because we had been obliged to make a long stop at South Brooklyn to take on the mail and some provisions, the dinner bell sounded long before we reached the dredges. Dinner on board a tug was quite a novelty, and we enjoyed it

immensely. When we returned to the pilot house, the captain pointed ahead.

"There is one of the dredges."

"Where?" we asked, straining our eyes, to make out something on the horizon.

"Right there before you, about half a mile off," said the captain.

"You don't mean that steamship?" asked Bill.

"Why, yes; don't you know what a dredge looks like?"

"I have seen lots of dredges," I said, "but they didn't any of them look like that."

"Oh, you're thinking of bucket dredges," said the captain. "We couldn't possibly use bucket dredges here. Every time a little storm came up, we would have to tow the dredge in, or else it would pound itself to pieces against the mud-scows. Bucket dredging is slow compared to this kind. These are suction dredges. The same difference as between taking a glass of soda-water in spoonfuls and drawing it up with a straw."

"But what do they do with the mud? Don't they have to have scows alongside?"

"In the first place, it isn't mud, at least not much of it. It is mostly sand and gravel. What a suction dredge devours goes into bins in her own hold, then it is taken out to sea and dumped. Do you see how low she is in the water? I guess they have just been waiting for us before putting out to sea to dump their load. I see the other dredge is over at Rockaway Inlet. I'll put you aboard this

dredge, and by the time I get back from Rockaway, you will have dumped your load and returned."

In a few minutes we had come alongside the dredge and climbed over the rail to her deck. Then we felt heartily ashamed of our old clothes, for everything on board was so spic and span. The tug captain called out to a Mr. Porter, who was the engineer on board, and consigned us to his care. The first thing we did was to apologize for our shabby looks.

"Oho!" laughed Mr. Porter, "you thought you were going aboard a mud scow, did you? So that's the reputation we have, and here we have always prided ourselves on our cleanliness. But even though this vessel gobbles thousands of tons of mud and sand, I'll guarantee you won't find any of it outside of the bins. We are ready to go down to dinner now. Won't you have a bite with us?"

"No, thank you," we replied, "we have just had a first class meal on the tug."

"Well, then, make yourselves at home, while we dine. You may wander around as much as you like and take in all you can, then after dinner, I will go around with you and answer questions."

While Mr. Porter was gone, we walked about the deck, trying to understand this curious vessel. Just forward of the pilot-house, there was an enormous bin filled with sand. Some water was swishing back and forth over it as we rolled gently in the ocean swell. Aft there was another bin of the same size. The bins appeared to be divided into com-

partments by means of partition walls, but we found later, when the bins were emptied, that this was merely the framing at the top. Running lengthwise across each bin were two shafts connected by worm-gearing to a set of screw-shafts that ran vertically. There was also a large hand-wheel on each of the vertical screw-shafts.

"I wonder how they dump this load?"

"Why, I suppose they just run the pumps backward and disgorge the stuff," was Bill's wise reply.

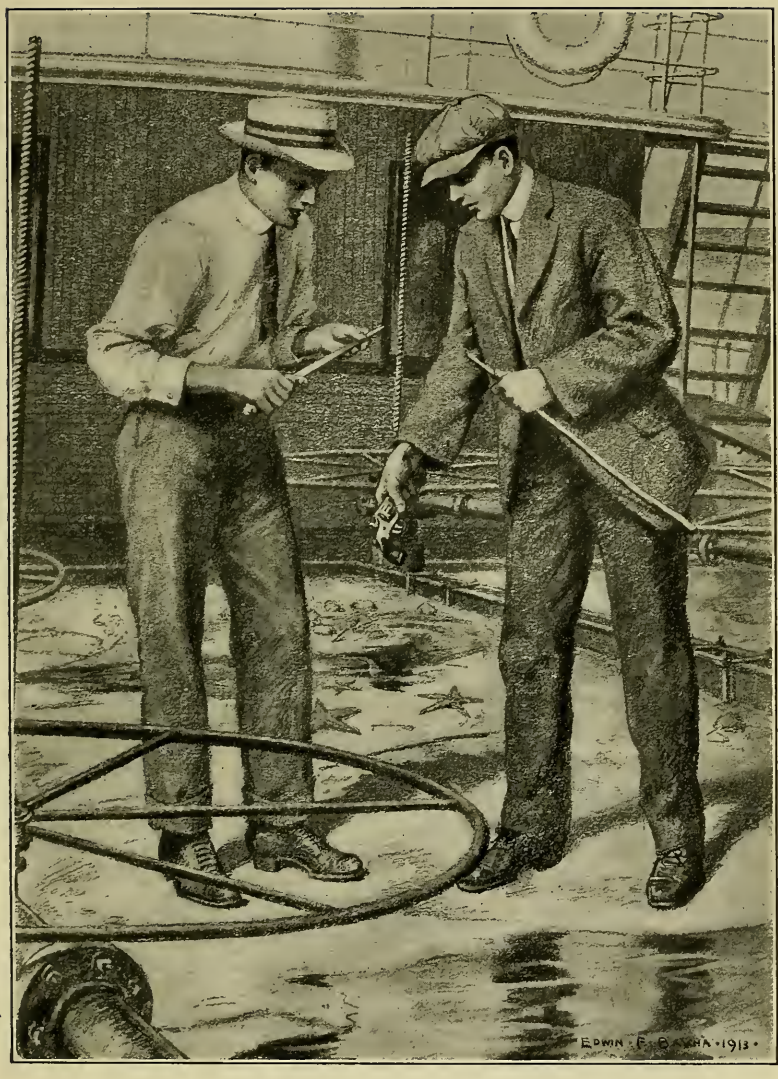
Presently, a couple of men came along. One had a stick with which he measured the average height of the sand in each compartment, while the other man jotted down the figures in a note-book, so as to determine the amount of sand in the bins. Then, much to our astonishment, the first man reached down into a puddle of water that overlay the sand, pulled out a good-sized fish, and laid it flapping on the deck.

"Good to eat?" we asked him.

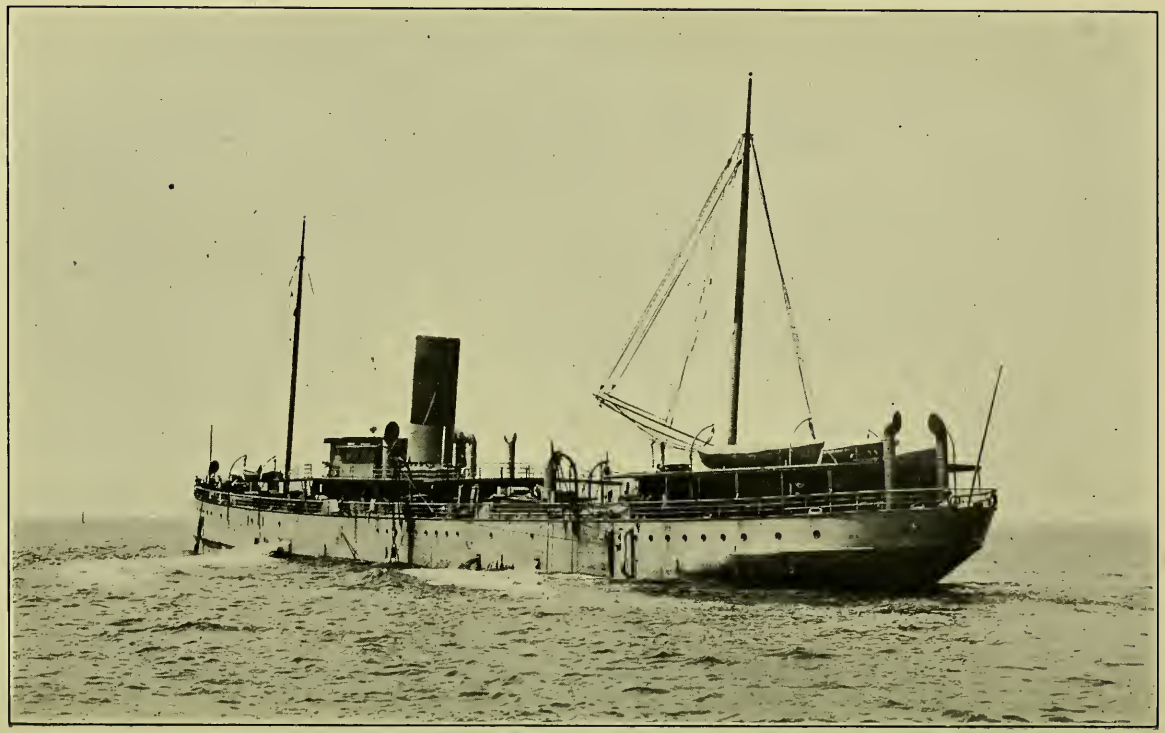
"Pretty good," he said; "it's a ling. We get lots of them. In fact, we get all the fish we care to eat. Big fellows, too, sometimes, all right fresh. We get plenty of lobsters, too. Didn't happen to catch any this haul, though."

We noticed a number of large starfish clinging to the walls of the bin, and as the man moved off I reached over to get one as a souvenir.

"Oh, look there!" exclaimed Bill suddenly, pointing to an object sticking out of the sand. Doesn't that look like a revolver?"



"THAT LOOKS LIKE PIRATES NOW, DOESN'T IT?"—See page 165.



ONE OF THE BOATS THAT DEVOUR MUD.

"It surely does," I replied; "I wonder if the sand is firm enough to hold us."

I tested it with my foot, and found it was as solid as a floor, so we both jumped over the side of the bin to pick up the curious object. A revolver it really was, an ugly-looking weapon, too, and pretty badly rusted.

"Now, where in the world do you suppose that came from?" asked Bill, as he sat down on the edge of the bin to examine it.

"Pirates!" I exclaimed.

"It couldn't be pirates," returned Bill, "the gun is too modern for that."

"Well, then, smugglers, maybe. Their boat has probably been wrecked here. I'll bet there's lots of treasure in this load of sand. Let's see what else we can find."

We began poking in the sand with sticks. Presently I struck something hard and black. In another moment I had uncovered an Italian stiletto with curiously carved handle.

"There," I said triumphantly, "that looks like pirates now, doesn't it? There is sure to be gold where you find pistols and knives."

A loud laugh interrupted me. "Ha, ha, ha! So you've got the gold fever, have you?" laughed Mr. Porter. "You've got your logic backward, young man; guns and knives are not an infallible sign of gold, but find your gold first, and then the firearms are sure to appear. We have found lots of firearms and daggers of every conceivable

form of ugliness, but as for treasure, it's mighty scarce, though I must admit that we have found some gold, too. It is too bad to spoil your romance, but there is no blood-curdling tale of piracy connected with those weapons, although, no doubt, they were once wielded by desperados. Some time ago, the police in New York got very busy, and started an active campaign against the carrying of concealed weapons. They rounded up the criminals and collected an enormous amount of junk. The only way of disposing of it was to throw it into the sea, but instead of taking it out to deep water, they dumped it in the Lower Bay, right in the path of this channel we are now excavating."

"But how about the gold?" I asked.

"Now that is not so easy to account for, but probably it happened in this way: A number of years ago, the garbage of the city used to be hauled out to sea in scows and dumped The work was done by contractors who were not overcareful to go as far as they were required to by the city authorities, and, when the patrol was not very vigilant, they would dump right into the bay. Now every one knows that valuable things sometimes find their way by accident into the garbage pail. This being the case, some of them are sure to find their way into our bins. One of the men who has been working here ever since the excavating began, has made a wonderful collection of coins. He has money from every part of the world—Spanish, Italian, Turkish, Chinese—and I don't know what not. Only the other day he picked up a silver crucifix. When you realize that we only find what

appears on the surface in the bins, you can imagine what a lot of careless people there are in a big city."

"I should think you would have some way of straining out the stuff," remarked Bill; "there must be a mint of money in it."

"It wouldn't be worth while. It would cost far more money than would ever be recovered. By the way, you had better get out of that bin now; we are pretty close to our dumping-ground. We have to dump in water that is at least ninety feet deep."

Presently, there was a rattle of machinery. The two worm-shafts began to turn, making the large hand-wheels rotate slowly, and feeding the screw-shafts downward.

"They are just 'cracking' the load," explained Mr. Porter, "to see that everything is all right before dumping."

" 'Cracking?' " we exclaimed.

"Yes, they have just slightly opened the gates in the bottom of the bins to see that they are not stuck, so that, when we dump the load, all the gates will operate together."

"But you don't mean to tell us that you dump that stuff out through the bottom of the boat?"

"Certainly, I do."

"But why doesn't the boat sink when you let the water in?"

"That's a foolish question," said Mr. Porter. "Stop and think about it a moment. Which is heavier, sand or water? Why should this boat sink if we swap a load of sand for a load of water? As the water comes in, the sand falls out,

and the boat, relieved of the weight of the sand, actually rises ten feet higher out of the water."

When they were "cracking" the bins, the sand sank a trifle, but presently the worm-shafts began to turn again, and, out of troughs at each side, there was a rush of water. The sand sank rapidly into the sea, melting away under the heavy streams.

"They're running the pumps now to wash down the sand," Mr. Porter explained. "It gets pretty well packed, and does not fall through the gates fast enough unless we help it along with some water."

As the sand fell away, we saw how enormous the bins were. "Each bin holds fourteen hundred cubic yards," said Mr. Porter, "and in the two bins there is something like forty-five hundred tons! But pshaw, I don't believe that conveys any idea to you. If you had to transport this sand over land, you would have to load it on a train a mile long, made up of one hundred and seventy-five cars, to carry off what this one vessel transports so easily. And what's more, it took us only two hours and fifty minutes to take on this load. We have been working here steadily for ten years, so you can just imagine we have sucked up quite a bit of mud and sand out of this old bay. The total excavation amounts to nearly seventy million cubic yards!"

Mr. Porter paused, evidently expecting us to express astonishment at the figure, but it would not have impressed me as anything very extraordinary had he said billions instead of millions, because the figure was way beyond my

comprehension. So I said nothing, and Bill only said "Uhu," in a very matter-of-fact way.

"Uhu!" mimicked Mr. Porter, "it doesn't seem to impress you very much. Let's put it another way. Suppose you should dump all this material in Broadway. You would choke the street from Bowling Green to Spuyten Duyvil to a depth of over two hundred feet. There, I thought that would astonish you," laughed Mr. Porter, as he saw our mouths open with surprise; "but it's true.

"See what a hullaballoo they are making over the Panama Canal, and yet all their excavation will not amount to much more than two hundred million cubic yards in a canal forty-five miles long, while we, with our seven-mile under-water canal, have just about one third of that amount to haul out. Why, boys, if this channel was being excavated on land where you could see its depth and width, the papers would be full of it, and we would be having crowds of sightseers out to watch the work. But we go on quietly, making no fuss and bluster, digging a channel nearly as wide as Central Park, and as long as from City Hall to One Hundred and Twenty-fifth Street. The channel has to be forty feet deep at low water and that means that we have to dig anywhere from ten to twenty-five feet into the bed of the bay to get the required depth, and all this without being able to see any of our work, but just moving our drags around and groping blindly in the dark."

"And has all this work been done with only one dredge?" Bill asked.

"Oh, no! we have had four here up to a short time ago. Now the work is nearly done, so there are only two of us here in the bay. The other dredge has just left us to help out with the work on the Rockaway Inlet. Yes, the work has gone on steadily night and day, year in and year out. We come in to our dock on Saturday afternoons and have Sunday ashore, but you will find us here at any other time, plodding along and sticking to it, rain or shine. Nothing but a howling gale drives us to shelter."

"What a lonesome job," I remarked.

"It does get rather monotonous at times, but we have our occasional excitements, too. Only the other day there was an incident that furnished just about all the excitement I care to have in a single dose. We were down at the entrance to the channel. There was such a heavy fog that we couldn't possibly do any work, so we lay there at anchor. Presently we heard the fog horn of a large vessel, outward bound, and then we made out the whistle of another vessel heading for port. Apparently we were right between the two and we kept our bell ringing to warn them off, but the whistling kept coming nearer. I was straining my eyes for a sight of the incoming steamer when all of a sudden it loomed up out of the fog less than two hundred feet away and traveling at a good fifteen-knot gait, too. Well, I say, she looked about the size of a mountain, and she was due to hit us amidships in another instant. We could do nothing but sound the alarm for every man to come on deck; but that vessel, it was a coast liner, made

one of the quickest turns on record. She just grazed us with ten feet clearance. Say, an experience like that unnerves a fellow more than you would think, unless you went through it once. It doesn't take five minutes for the thing to happen, but the shock stays by you all day. You can't understand it unless you have actually experienced it. Suppose you were walking along Broadway and a safe should fall from the top of a twenty-story building and bury itself in the sidewalk not more than a yard in front of you, you'd experience a sensation, wouldn't you? Well, that's what happened to me once, but I tell you the shock was not one whit more unnerving and unexpected than the sight of that big steamer threatening to send us to the bottom with only a couple of minutes' warning."

Mr. Porter looked pleased at the impression this made upon us. "Oh, yes, we have excitement enough sometimes. Every now and then we rescue a motor boat or launch that gets caught in a sudden squall. Occasionally we have excitement of a different sort. They are supposed to be very particular where they point their guns at Sandy Hook, when target shooting, but more than once, we have had shells fall dangerously near us. You know you can see those shells in flight. Once I was standing right by the forward bin when I saw a shell strike the water not far from us on our starboard side and then recochet directly toward me. I fell flat on the deck while that shell went screeching over me. The captain can testify that it passed right between that mast there and the pilot house, and

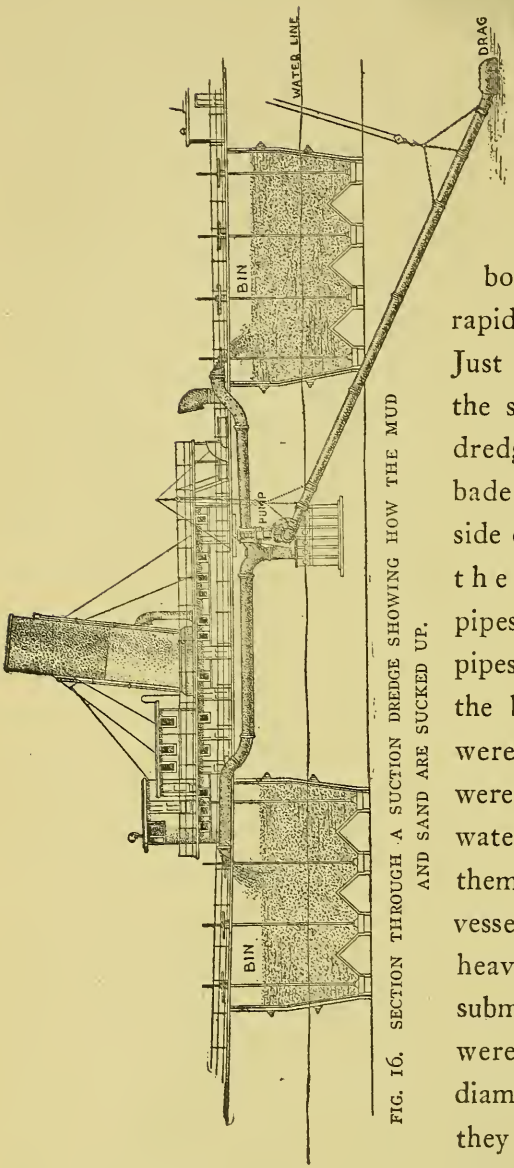


FIG. 16. SECTION THROUGH A SUCTION DREDGE SHOWING HOW THE MUD AND SAND ARE SUCKED UP.

say, that is as close as I want to get to one of those things in time of peace."

All this time, the boat was steaming back rapidly up the channel. Just before we reached the spot that was to be dredged, Mr. Porter bade us look over the side of the vessel and see the enormous suction pipes. There were two pipes, one at each side of the boat, and while we were going along they were raised out of the water. We had not seen them before because the vessel was loaded so heavily that they were submerged. The pipes were twenty inches in diameter, and, where they entered the hull, they were fitted with

swivel-joints. At the opposite end of each pipe, there was a "drag," or a sort of mouthpiece, about five feet broad. The mouthpiece was partitioned off so that the openings in it measured about eight by nine inches.

"Anything that can go through those openings," explained Mr. Porter, "will go through all the rest of the

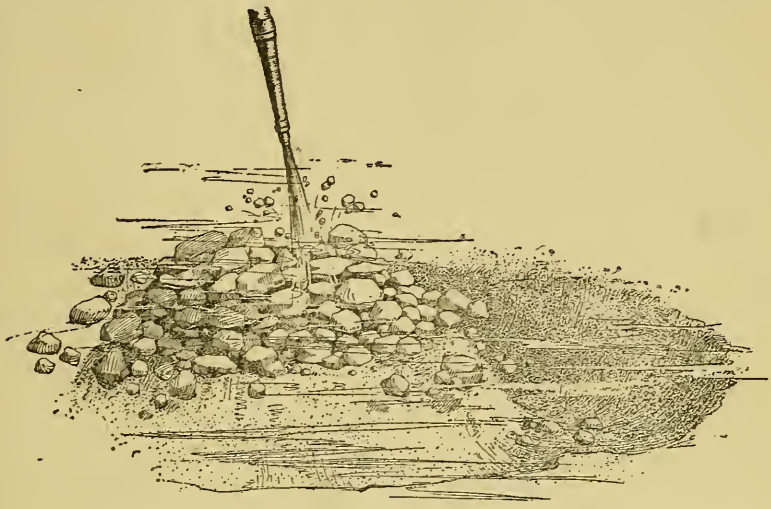


FIG. 17. BURYING A STONE PILE WITH A WATER JET.

system. It doesn't matter how heavy it is, the water will carry it right up into the bins."

"Suppose you should strike a rock bigger than eight by nine inches," I asked; "what would you do?"

"We would just dig a hole in the sand and bury it."

"Bury it!" I ejaculated.

Mr. Porter's eyes twinkled. "I astonished you again, didn't I? There are lots of stone piles along this channel. Nobody ever thought that the channel would be dug

through here, and there used to be no regulation against dumping rock in the bay. We can't suck up that rock because there is too much of it. All we do is to dredge a deep hole around the stone pile fifteen or twenty feet deep, and then the survey-boat comes along with a water-jet that loosens up the pile, and topples it over into the hole."

We looked puzzled. "Yes," explained Mr. Porter, "they play a stream of water on the pile just as you might play the garden hose on a sand-hill. You can use the water-jet under water as well as anywhere else."

Presently we saw the drag lowered into the water. The pumps were started, and enormous streams of water poured boiling and churning, out of the square conduits at each side into the bins. Soon the water turned muddy, but the river of sand we expected to see failed to appear.

"Is that what you pump up through the dredges?" Bill asked.

"Yes, it is mostly water, but soon the bins will fill up, and then the water will flow over the top into an overflow channel, while the sand and mud settle to the bottom."

So this was the dirty dredging operation that we had prepared to see! The only thing objectionable about it was an unpleasant odor that arose when the drags began to suck up some of the surface mud.

Mr. Porter took us below and let us see the big pumps at work. There were two centrifugal pumps about ten feet in diameter, driven by 450-horse-power engines. Every now and then, we heard a bang and a crash as a large stone

was carried through by the torrent of water, while there was an almost incessant rattle of small stones through the pipes. It was extremely interesting and quite marvelous to think of those two drags groping blindly along the bottom, devouring everything that came within their reach. Mr. Porter explained that the boat had to keep moving lest the tide or some current carry it backward, jamming the suction pipes, and breaking them.

When we got back on deck, we found, much to our regret, that the tugboat had returned, and we had to cut our visit short.

CHAPTER XVIII.

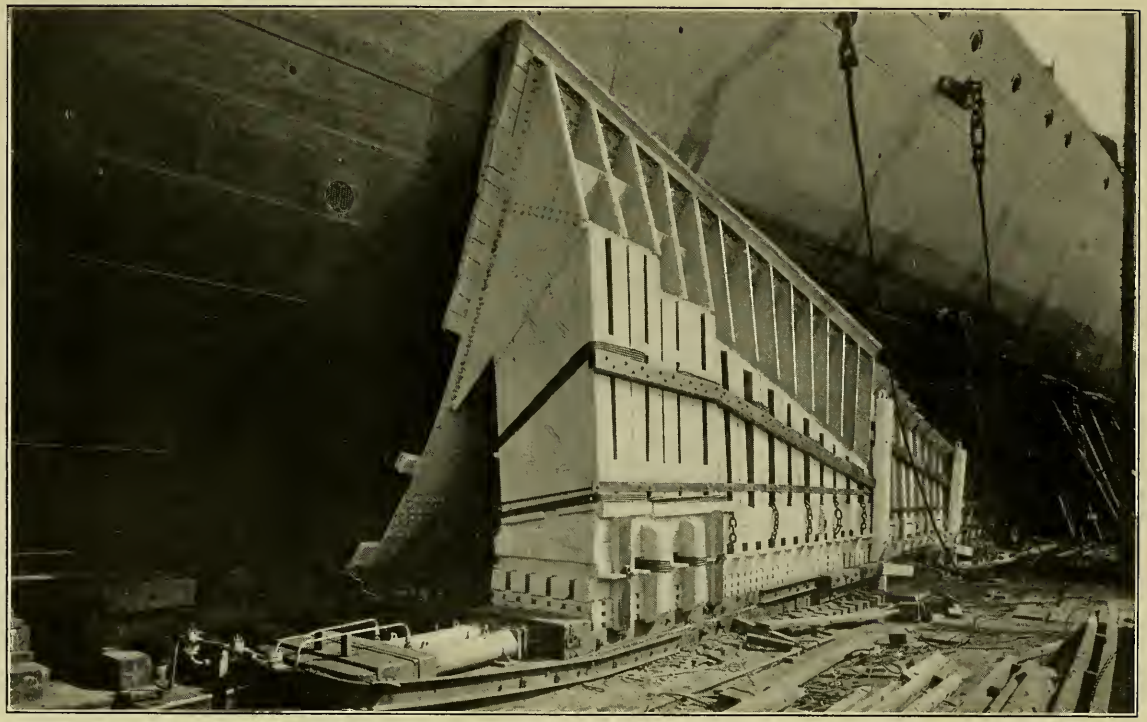
THE LAUNCH OF A BATTLESHIP.

THE telegram read: "Battleship to be launched at Navy Yard this morning. Telephone one column."

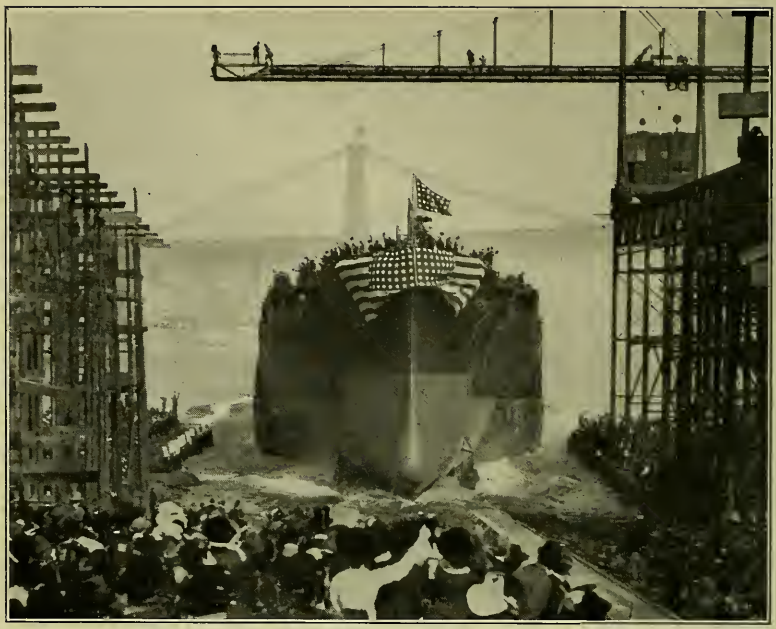
It tickled me to get these communications from the City Editor. It meant money. Money that I was earning, and it put me more on an equality with Bill and his thousand dollars. Of course Bill always treated me as an equal and as if Uncle Ed had given that thousand dollars to me as much as to him, but somehow I didn't feel just that way about it, and I couldn't quite forget our little tiff on the first morning. So it was that I welcomed every chance to earn a dollar or two. The articles were prepared by both of us together. Bill did his part with sketches and the figuring of comparisons and criticism of my style, but the actual writing was done by my hand, and so I felt that I was contributing my part toward our summer's outing.

The Navy Yard was one of the places we had decided to visit. We were anxious to go aboard a battleship, and here was our chance to carry out our plans while incidentally earning some more money.

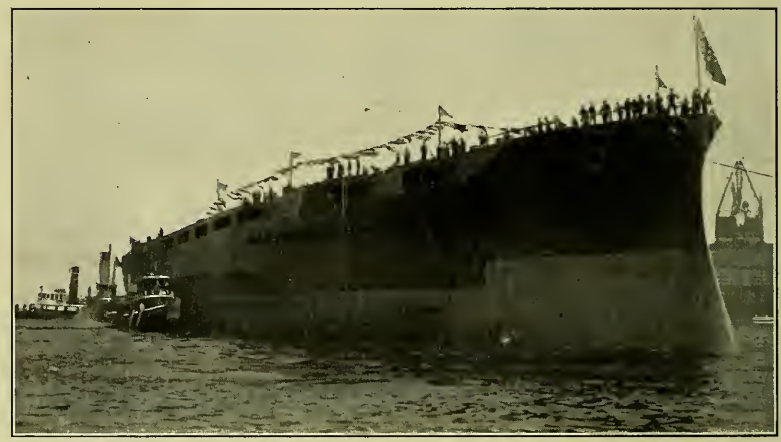
I wonder how many boys ever stop to figure out just how a battleship or any other vessel, for that matter, is launched.



BOW CRADLE. IN THE FOREGROUND ARE THE HYDRAULIC RAMS FOR STARTING THE SHIP DOWN THE WAYS.



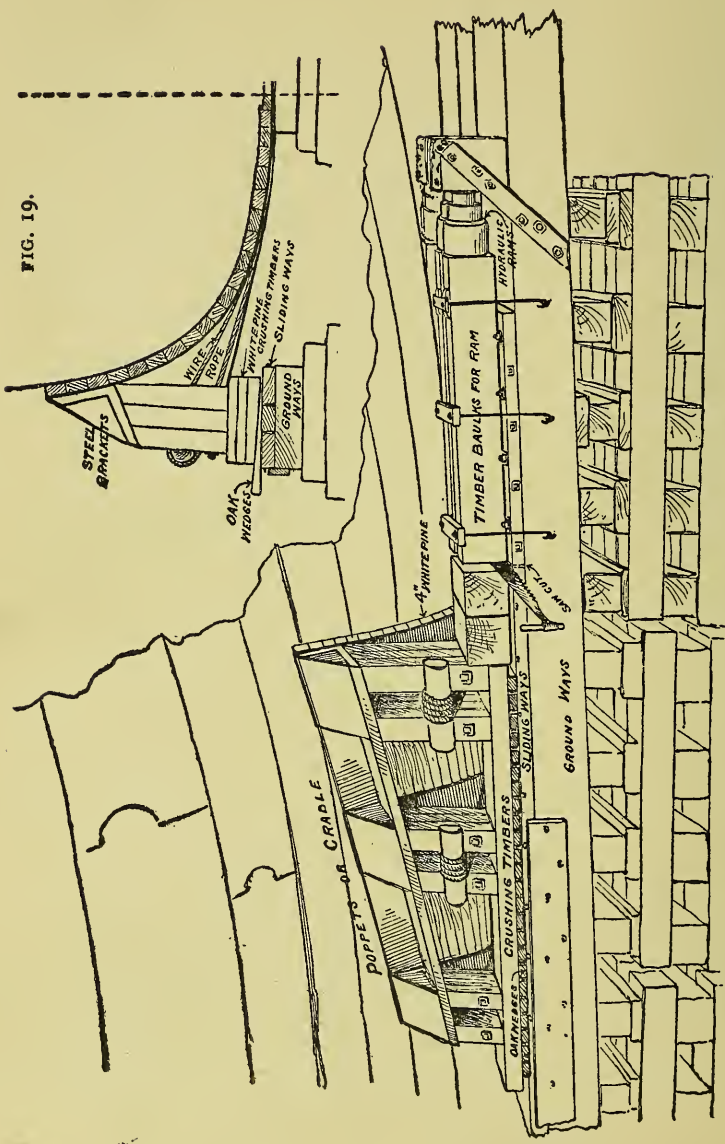
U. S. BATTLESHIP "NEW YORK" SLIDING DOWN THE WAYS.



CAUGHT BY THE TUGS AFTER THE LAUNCHING.

I never had, and Bill and I argued it all out on the trolley going over. But the schemes we suggested were all wrong. A battleship is a pretty heavy thing, you know. This one weighed ten thousand tons—just the bare hull without any heavy machinery. The idea of mounting such a heavy ship as this on wheels or rollers, as I suggested, was absurd. If it were supported wagon-fashion on four wheels, the hull would be apt to crumple up in the center, of its own weight, because boats are not intended to be put to such uneven strains. When in the water they are supported throughout their entire length. It was an exceedingly ticklish job, moving an object so huge and unwieldy.

We reached the Navy Yard long before the launching and had plenty of time to study operations before the crowd arrived. The battleship had been built out in the open, right along the shore, on a special foundation. First, rows of piles were driven into the ground to furnish a solid bearing. Spiked to these piles were tiers of heavy timbers, the first tier running across the foundation. The upper tiers were made of beams laid crisscross and arranged in three parallel lines, one running under the keel and one at each side under the bilges. While the ship was under construction its weight was carried by the center keel blocks and hundreds of shoring timbers. These shoring timbers had all been removed before we arrived on the scene and the two parallel lines of timbers, which are known as "ground ways," were bearing their share of the load. The ground ways ran down into the water a considerable distance. They



FIGS. 18 AND 19. HOW THE SHIP IS SUPPORTED IN A CRADLE ON THE LAUNCHING WAYS.

formed the tracks, so to speak, on which the sliding ways were to travel, and they were well lubricated with thick grease. The sliding ways were made of hard wood, bolted fast to the ground ways. They were kept from slipping off the ground ways by projecting planks bolted to the outside of the ground ways to form flanges. The sliding ways carried cradles or "poppets" in which the ship was supported. Figs. 18 and 19 show the arrangement. The cradles were made up of broad steel straps, that ran under the keel and were fastened to steel brackets. The space between the hull and the straps was filled with white pine timbers, and the cradles were drawn up against the hull by means of steel wire and reinforcing bars. Between the sliding ways and the crushing timbers, which formed the bottom of the cradles, wedges of oak were driven in. Half an hour before the launch hundreds of workmen ranged themselves along each side of the ways and drove those wedges home with heavy sledge hammers, lifting the great hulk off the keel blocks, so that it was actually carried in slings.

"But what in the world keeps the vessel from sliding down the ways," we queried.

"Glycerine," was the laconic answer of one of the mechanics. "Fact," he continued, as he caught our incredulous smile. "New scheme. Going to try it out for the first time this morning. We used to bolt the shore ends of the sliding ways to the ground ways, and then when the signal came, we would saw through the sliding ways just beyond the bolted part until they broke off with a bang. Then down

would go the ship (Figure 18 shows where the ways were cut.) If she stuck we would give her a shove with a pair of hydraulic jacks. This time we are using a heavy steel trigger, like this"— and he made a rapid pencil sketch similar to Figure 20. "The steel trigger is pivoted in the ground ways and hooks against a cap on the sliding ways to keep them from sliding. The trigger is held out by a hydraulic piston. Glycerine is used in the cylinder to force

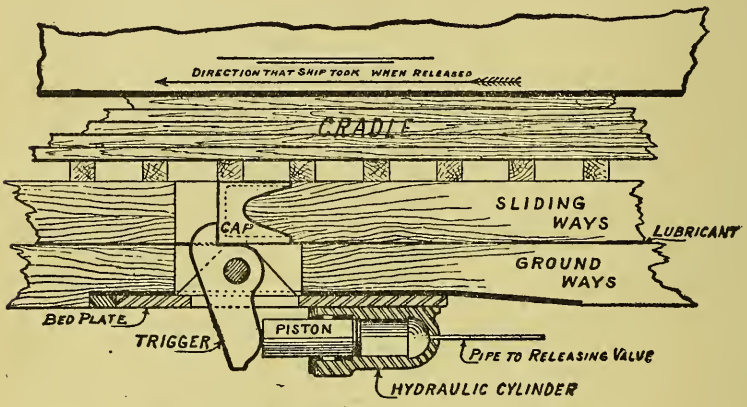


FIG. 20. THE HYDRAULIC LAUNCHING TRIGGER.

the piston out. So you see it is the glycerine that keeps the boat from sliding down the ways. When the signal comes, somebody will turn a valve to let the trigger out and then the piston will slide into its cylinder and the trigger will let go of the sliding ways and off will go the ship."

I was jotting down all this information and as soon as I had the complete story, I rushed off to telephone it to the *Evening Sphere*. Then I hurried back to Bill.

The crowd was gathering rapidly now. Mr. Watkins showed up presently and asked us how we were getting along. Bill started to explain the launching ways, but he wouldn't stop to listen. "I never was much on machinery," was his excuse. "You can have that part of the story all to yourselves."

The engineer in charge of the launching was walking up and down the ways, personally inspecting every detail. "And a ticklish job it is," said the mechanic, "it has house-moving beat a mile. That boat cost a penny or two, I'll have you know, just as she stands without her armor and machinery aboard. If there was any hitch it might cost lots more money, and that engineer would never hear the last of it."

The vessel was to be launched stern foremost, as all vessels are, but, unlike other ships, this one had its propellers in place. We learned that there was no dock in the neighborhood of New York large enough to take a battleship of the size of this one, and so the propellers had to be mounted in place before the vessel took to the water. One of the details that the engineer had to scrutinize very carefully was the boxing around the propellers, for when the vessel slid into the water, the impact might be enough to injure them, were they not very carefully protected.

In the meanwhile officials were arriving at the grandstand far overhead. There was a bustle of activity. The vessel was surrounded by a sea of spectators. Thousands of watches were out. The ship was to be launched at 12, noon.

After an interminable wait a factory whistle sounded. At the same instant the hydraulic valve was turned and the words rang out in a shrill, feminine voice, "I christen thee—" but the name was drowned in the crash of the champagne bottle against the retreating hull. Down slid the big boat, gathering momentum at each second. It was an anxious moment. Would anything happen to mar the event? The stern plunged into the water. In a moment the vessel had floated clear, and several tug boats immediately made fast to it. The cheers completely drowned out the music of the band. Everybody swarmed over the ways to pick up pieces of the thick, hardened, orange-colored grease.

We hurried off to the telephone. On the way we heard the gasp of escaping air.

"That sounds familiar," cried Bill. We turned down one of the side streets and came upon a forest of caissons and excavating machinery. They must be going to put up a pretty big building there," I ventured.

"I'll stop and investigate," said Bill. "There is no need of my going with you."

"All right. I'll look for you when I get through."

Most of my story explaining the launching apparatus had already been sent to the *Sphere*. All I had to do now was to add a little about how smoothly the launching had been carried out.

CHAPTER XIX.

THE "HOODOO DRYDOCK."

WHEN I returned I found Bill full of excitement over his find.

"What do you suppose," he exclaimed, "it isn't a sky-scraper they're building, but a hole in the ground."

"A hole!" I exclaimed. "Stop talking in riddles."

"Yes, a hole, and the whole navy yard has been trying to slide into it. Look at that building there." It was one of the workshops and the entire front had given way.

"But what do they want such a hole for?"

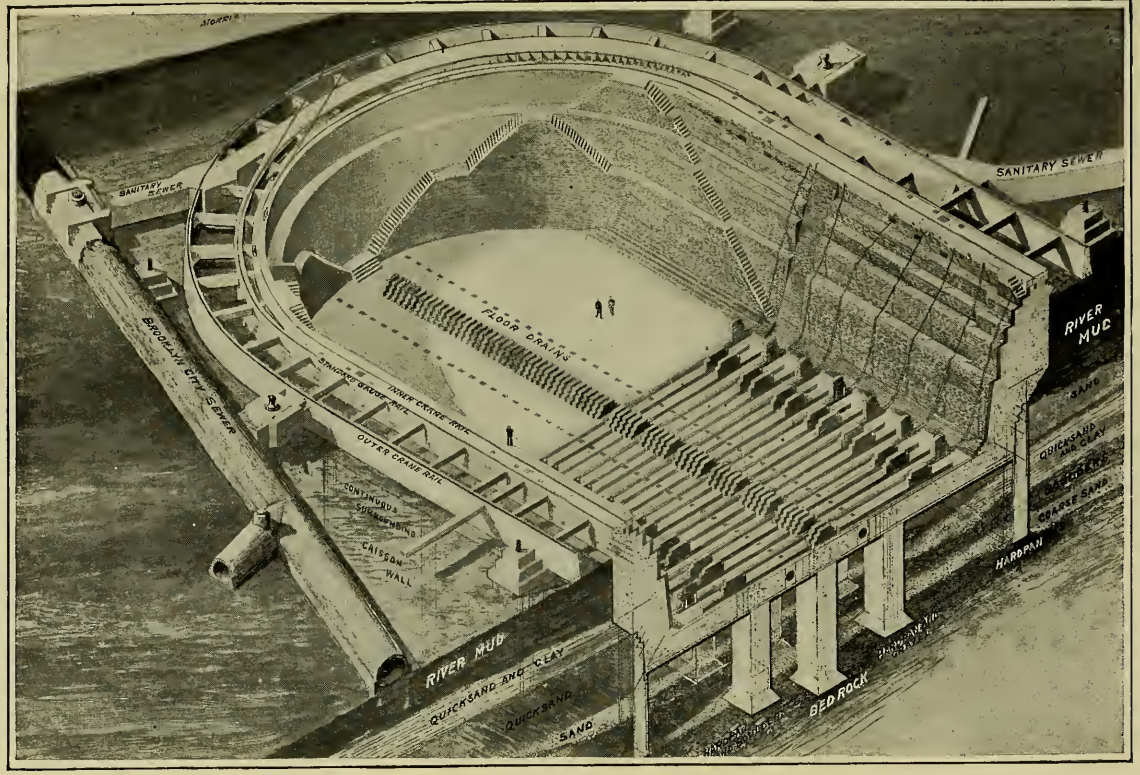
"For a drydock. They let the boats sail in and then they shut the gate at the end and pump out the water so that they can scrape and paint the hull of the vessel or do any repairs that are necessary."

"Oh, I know what a drydock is, but I don't see why they have so much trouble digging it."

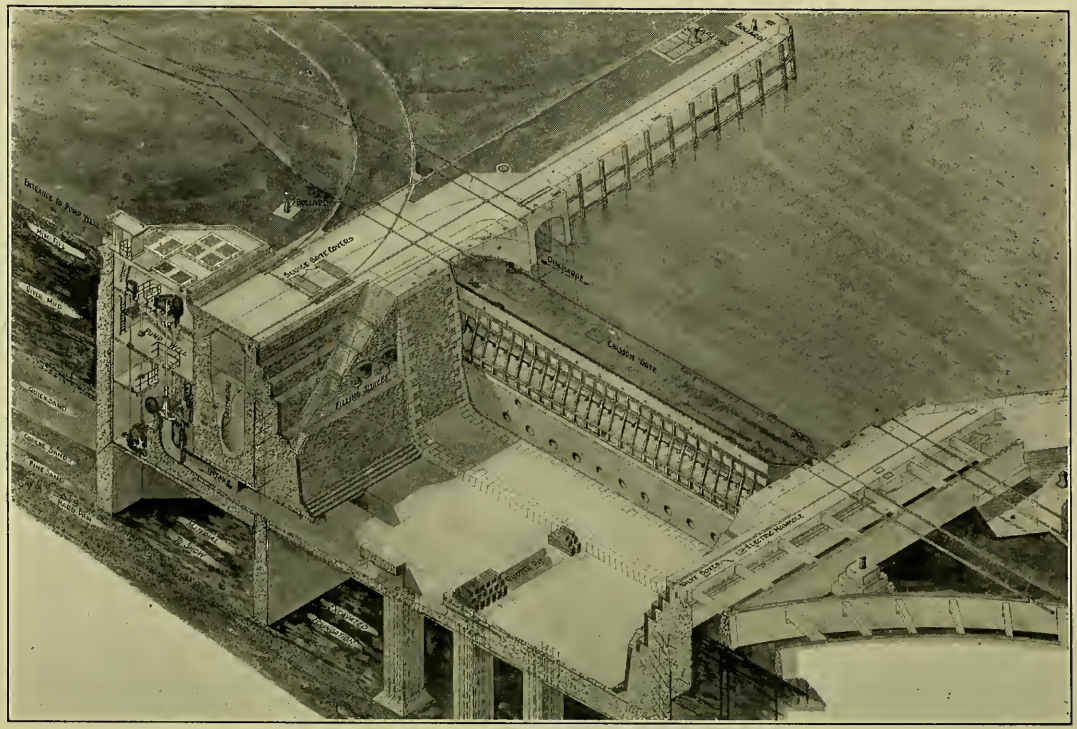
"Oh, they have had a terrible time," said Bill. "I have just been talking to one of the engineers. They have been working at this particular hole for years. It's called the 'Hoodoo Drydock.' Two contractors gave it up, after spending thousands of dollars on it, and now this one is trying a brand new scheme. Come over this way and meet Engineer Edwards. He'll tell you all about it."

"We have the worst kind of soil imaginable here," said Mr. Edwards, after I had been introduced. "It is made up of layers of mud and quicksand and there is no bedrock except so far down that it is impossible to sink caissons to it. The quicksand is very treacherous stuff. The first fellow that tackled the job thought he would build a wall all around the dock by driving sheet piling to the hardpan below it. The piling was made of sheets of steel with grooves at one edge for the next pile to fit into so as to make a continuous wall.

"You see if he could build a cut-off wall like that and make it strong enough to withstand the pressure of the sand back of it, he could dig out the sand inside the wall without having a lot of new sand pouring in all the time. But the trouble was that he couldn't drive his sheet piling down without striking boulders every now and then that would twist the metal out of shape. Then when he dug out the ground inside the walls the quicksands shifted the walls of piling and boiled up through the thin layer of clay at the bottom into the excavation. He planned to lay the floor of his drydock on wooden piles driven as close together as possible, but the sand below, was so fine and so fluid that the piles wouldn't stay down. The thin, clay blanket at the top would hold them for a time and then they would work loose and bob up, actually floating in the fluid sand layer. Troubles came thick and fast and so the contractor threw up the job. The next man thought he could keep ahead of the water and sand that filled the excavation,



A SECTIONAL DRAWING OF THE "HOODOO" DRYDOCK.



SECTION THROUGH THE DOCK SHOWING THE CAISSON GATE AND THE PUMP WELL.

by pumping it out as fast as it poured in, but there was no limit to the stuff that kept boiling up through the thin clay floor, and the first thing he knew that machine shop over there began to settle. The pumps were sucking the sandy foundation from under it. The entire front of the building caved in. But the worst was still to come. There was a large trunk-line sewer running through the yard near the dock. The soil support under the sewer was sucked out by the pump, and, finally, the sewer itself was put to such a strain that it broke, and the sewage began to pour into the excavation. Soon the hole was a vast, evil-smelling cess-pool. There was nothing to do but dig up the sewer and repair it, and then pump the hole clear of the sewage. This was too much for the second contractor, and he gave it up. Now we are building on a somewhat different plan. We are constructing a cut-off wall of solid concrete all around, five feet thick, and running down 80 or 90 feet to a layer of hard clay, and it looks as though this method would accomplish the trick."

We could see that there was a complete ring of caissons running all along the dock, and I jotted down the size of the dock as given me by Engineer Edwards. It was 110 feet wide, or about half the width of an ordinary city block, and 726 feet long, or as long as three New York city blocks. The caissons were only 36 feet long, and so you see it took quite a number of caissons to complete the entire circuit.

"Down in No. 38 and in 31 too," said Engineer Edwards, "they are cutting away some of the old sheet piling

which was crumpled up so badly by the boulders they struck, that it lies in the way of the caisson work. They are using the oxy-acetylene torch."

"What?" I asked, alive to the dangers of a torch in a caisson.

"Why, a torch that eats its way through the steel and iron. The torch burns acetylene and oxygen. Just enough oxygen is mixed with the acetylene to make the hottest kind of flame. The heat is so intense that iron melts under it, almost like butter. It makes a clean cut, too. You can cut your name through a plate two inches thick with one of those torches, just as neatly as if it had been done with a scroll saw through a quarter-inch board."

"Say, won't you let us see them at it?" we exclaimed.

"What, under pressure? Why, young men, do you understand that we are using an air pressure of 35 pounds on every square inch."

"Oh, we are old timers," I declared. "We have been under pressure before. The fact is, we worked as sandhogs for a week under the East River. We were there when Jerry was blown out of the tube through the bottom of the river, and we were in the caisson where Danny Roach was so badly burned a few weeks ago."

"You don't say so," exclaimed Engineer Edwards, "then you might as well come along."

We climbed into one of the buckets that was being lowered into Lock No. 38, and soon found ourselves in the long, narrow working chamber.

"Why, it's a wooden chamber," exclaimed Bill. "Aren't you afraid of setting it afire?"

"Oh, we've done that often," said Mr. Edwards, "but we are always on the watch for trouble and have wet sand on hand to bury the blaze, and once or twice we have had to flood a caisson to drown a fire."

"At the far end of the caisson there were two men operating the torch to cut away a crumpled piece of heavy sheet iron that had turned at right angles clear across the working chamber. They had to cut through it at both sides of the chamber to clear the way for the cutting edges of the caisson. When I saw the blast of the acetylene torch blazing white hot so close to the wooden walls of the chamber, it brought back to me the horror of the blazing oakum and flaming clothes on poor Danny Roach.

"You might think that the blast of this torch would be much greater and fiercer in this compressed air than outside," said Mr. Edwards, "but you see the acetylene is mixed with all the oxygen it needs so that it would blaze just the same if there were no air at all in the chamber. The heat of the torch is 6300 degrees Fah., and steel melts at about 2500 degrees, so you see it is almost like cutting butter with a jet of boiling water."

It was indeed remarkable how quickly that sheet of metal was cut away. It was melted through as cleanly as if cut with a knife, and the cut was no more than half an inch wide. With the torch it was sliced into pieces of convenient size, to be packed into the bucket and be hauled

through the narrow lock to the surface. Once while burning away the steel at the cutting edge the wooden walls of the working chamber caught fire, but a man who was on watch for trouble, smothered the flame, immediately, with a pail of wet sand.

When we had seen all there was to see, Engineer Edwards took us over to a caisson at the middle of the dock. "They're doing some rather unusual work down there," he said. "The caisson has been sunk to a depth of 95 feet below water level, and we are now in a layer of hard clay which, although not by any means as good for a foundation as a solid rock, will have to do, because we cannot economically go much further on account of the air pressure required. We are using over 48 pounds now, and the men are at work only an hour and a half at a shift."

We have never been under such heavy pressure before, but our guide, personally, tended to the air valve and let in the compressed air so slowly that we did not feel very uncomfortable. When we reached the bottom of the shafting, we were astonished to find that the working chamber flared out on all sides and at a decided angle, so that while it was only seven feet square at the top it was fully ten feet square below.

"How did you manage to sink a chamber of that shape?" I inquired.

"We didn't," said Mr. Edwards, "we built the walls of the chamber as we went along. Watch that man over there and you will catch on to what I mean."

The man was driving short lengths of planking at a slant into the ground. The planks were mortised and tenoned together and made a continuous wall. Then I noticed that the slanting wall was made of several layers of such planked piling, one layer overlapping, or, more properly speaking, underlapping the next, as in Figure 21.

"We can't use very long piles in such cramped quarters," explained Mr. Edwards, "and even if there were plenty of head room we couldn't get planks more than six feet long through the air locks. We are nearly through with this footing. It will spread over an area of eleven feet square when it is done. Then it will serve to keep the dock down, as well as up."

"How, keep it down?" I queried.

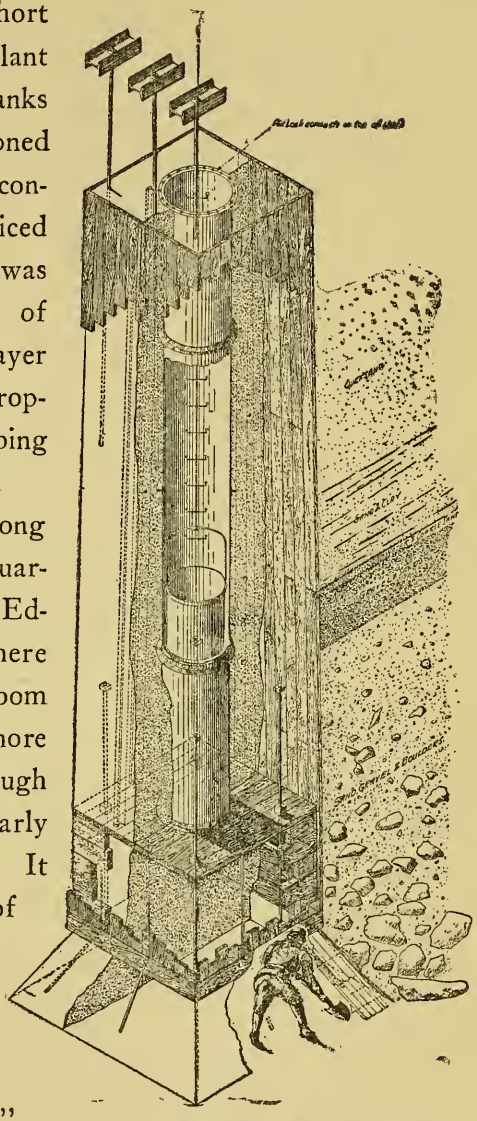


FIG. 21. MAKING A FLARED FOOTING FOR A CONCRETE COLUMN.

"Why, a drydock is subjected to some very curious strains and stresses when built in such treacherous soil as we have here. It is really an enormous flat-bottom concrete boat. When the end gate is open and it is flooded with water, it is like a sunken vessel; its weight rests heavily on the bottom. After a heavy battleship is docked in here, and the water is all pumped out, the dock will be light enough to float, battleship and all, but the battleship will impose such a concentrated load on the bottom of our concrete boat, that it would be apt to break under the strain. That is why we are sinking piers like these with spread foundations to take the load. There will be three rows, twenty-four feet apart, down the center line of the dock, with the piers spaced twenty feet apart in each row. When the dock is pumped dry and there is no vessel in it, there will be an enormous upward thrust caused by the water pressure under the floor of the dock, which would tend to lift the dock bodily out of the ground. The side walls will be heavy enough to stay down, but the floor, which will be a slab of concrete, only eight feet thick, would give way under the pressure were it not held down by the piers with their spread footings. See this dock displaces so much water or fluid sand, that although we have sixty thousand cubic yards of concrete and two hundred thousand tons of steel in it, our concrete boat would float well out of water with its foundation piers and all, were it not actually held down by the flaring footings and the friction of the ground on the side walls."

"Sixty thousand cubic yards," exclaimed Bill, making a rapid calculation, "why, that would make a solid chunk nearly one hundred and twenty feet on each side."

"Yes," said Engineer Edwards, "and if you built it into a 10-foot wall, a yard thick, it would be over ten miles long."

"Oh, look at that lock," said Bill, when we had returned to the surface. "It doesn't look as though a man could much more than squeeze through. Why do they have to make it so small?"

"That is a 'key' between two of the caissons. You notice how all the caissons in the cut-off wall have half-round forms in them so that between them they leave a circular well. Now we are just cutting out the timbers from the half-round sections, and then the shaft that is formed will be filled with concrete."

The half-round sections he referred to are shown in Figures 22 and 23. Temporary forms were built into the caissons as each section was added, leaving a half-round hollow shaft more or less filled with timbers. There was a similar half-round shaft in the adjacent caisson, and together they formed a cylindrical well three feet in diameter extending from the surface to the decks of the working chambers, with the adjoining walls of the caissons forming a central partition. It was this partition that had to be cut away, and the timber work of the forms had to be removed before the well could be filled with concrete to key the two caissons together. Mr. Edwards explained how they would proceed

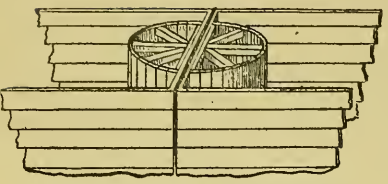


FIG. 22. HALF-ROUND FORMS IN A CAISSON.

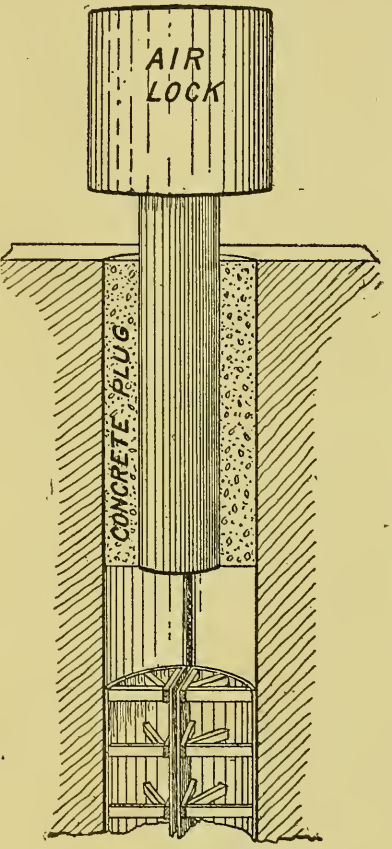


FIG. 23. A KEY SHAFT BETWEEN TWO CAISSONS.

with the work, as far as they could, before water leaked into the shaft between the two adjoining walls of the caisson. Then they would cork up the top of the shafts with a plug of concrete, leaving a small shafting in the center to provide access to the interior. It was on such a shafting as this that the men were putting the small air locks. Once the airlock was in place they would force out the water as far down as the partition was cut, stopping up the crack between the caissons with clay and oakum. Engineer Edwards told us of a frightful accident that had happened once when he was on a similar job. The man who was stuffing in the oakum accidentally set fire to a bunch of it. We knew what fire in a caisson was, but this accident was far more serious than the one we had experienced.

There was no chance of getting out of the way in a shaft only three feet in diameter and the blazing oakum dropped down on the helpless men, burning them so badly that all but one died.

"When the men clear up the timbers all the way to the bottom," Engineer Edwards continued to explain, "they'll cut into the wall of the working chambers and then they will begin to fill the well with concrete until the entire shaft is filled to the very top, bonding the two walls together. After the entire cut-off wall is completed, we shall begin to dig out the dock. To relieve the pressure against the walls, we are going to shore across from one side to the other with heavy timbers. Then we'll excavate a small section at a time and lay our flooring."

"But what about the entrance to the lock," said Bill, "you haven't a cut-off there, have you?"

"Oh, yes, we have. There are two cut-off walls there, forty feet apart. Extra heavy caissons are used, and they are filled with concrete up to the level of the dock floor, but empty above that. The space between these cofferdams, as they are called, is being excavated, and there the granite seat for the gate of the dock will be built. When the rest of the dock is done, the cofferdams will be cut away, and the granite work between them will be bonded to the rest of the dock."

"Do you hinge the gate to the seat?" I asked, having in mind the gates used on canal locks.

"Oh, no," laughed Mr. Edwards, "that would never do.

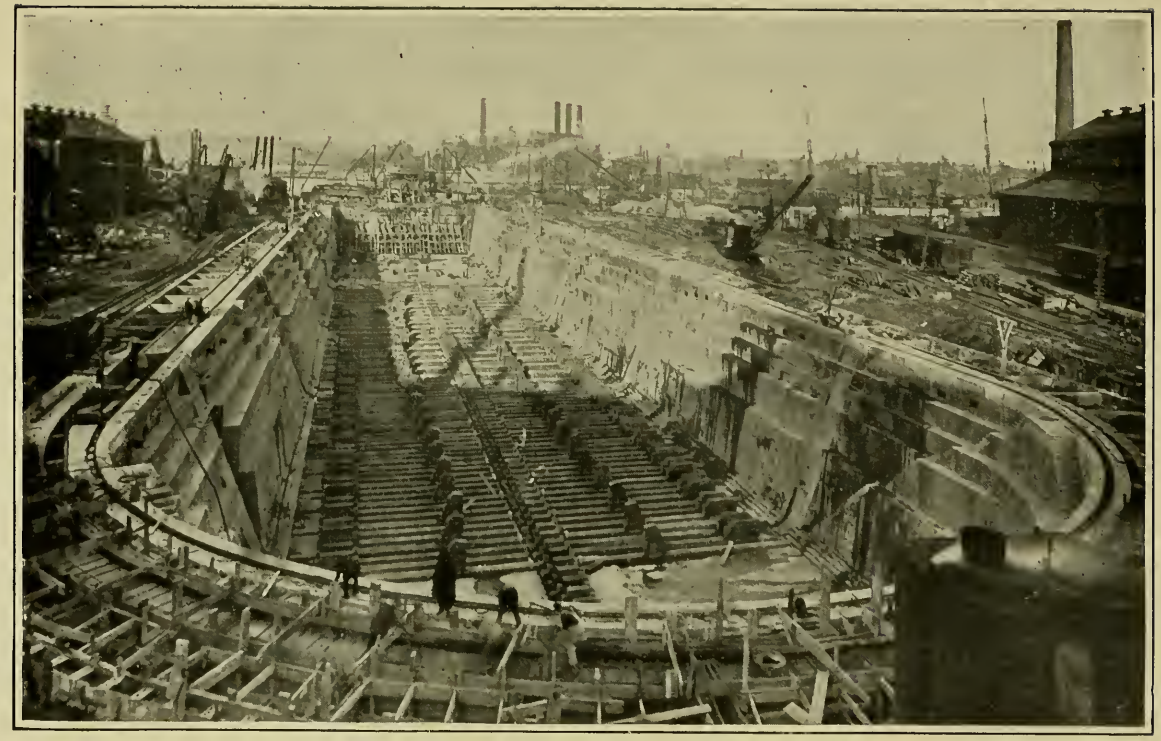
Haven't you ever seen a ship dock? Well, the Connecticut is due here the day after to-morrow, and is to be docked in No. 4. Why don't you come down and see the whole operation for yourselves?"

"That will be great," I said.

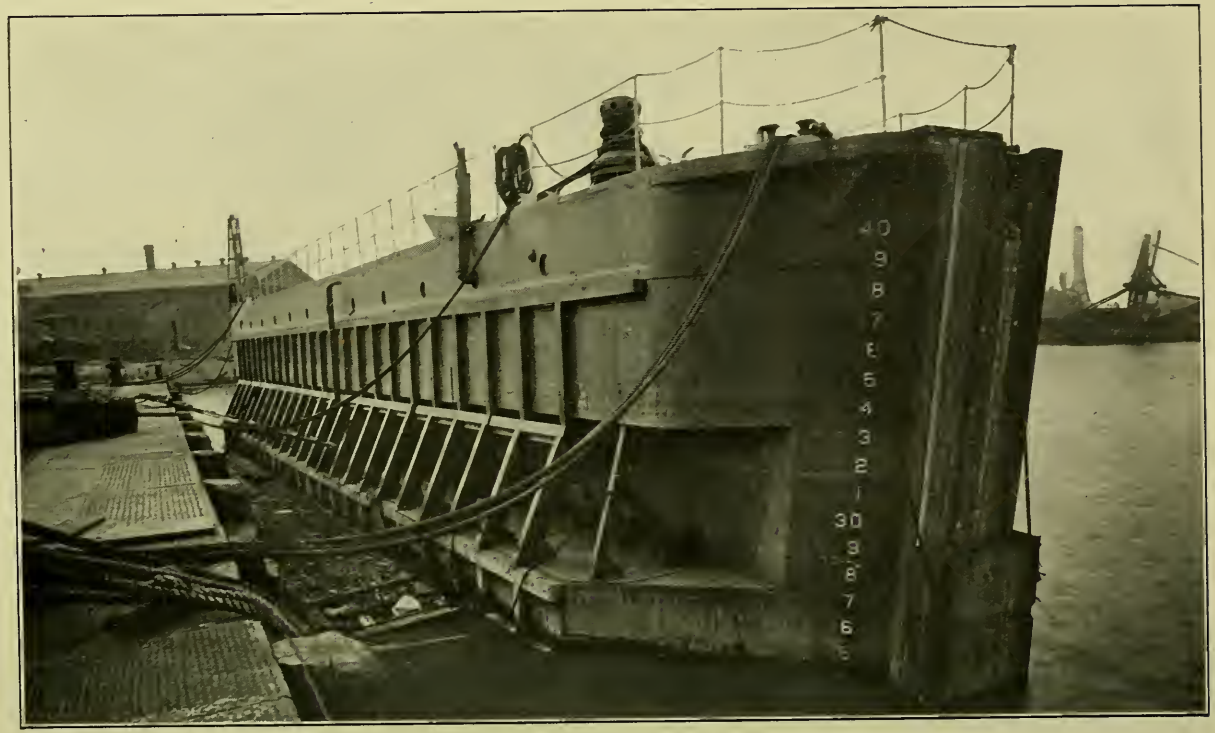
"Will you be there, so that we can ask questions," asked Bill. Engineer Edwards laughed. "You *are* a regular question mark. But that is the only way to learn, and I am only too glad to give you all the information I can. I am afraid, though, that I shall be too busy to spend the day with you. Besides, if you become too inquisitive, you may 'stump' me with your questions. The master shipwright is the man you want to see. He always prepares the docks for the vessels. Here, lend me your note book, Bill."

Mr. Edwards tore out a leaf and wrote a note of introduction to Master Shipwright Lowry. "There, take that over to Lowry in that long brick building over there, and see what you can get out of him."

Mr. Lowry certainly was a hard man to interview. He was willing enough to talk, but he used so many nautical terms and was so vague that we couldn't follow him. We gathered finally that it was far simpler to prepare a dock for a battleship than for other boats, because a battleship is flat-bottomed, and it is only necessary to lay three lines of blocks in the dock to receive it, all in a straight line, and all at just about the same level, while a round-bottomed vessel must have the blocks set to fit the shape of the hull, and then big, round timbers, or shores, must be



THE HUGE DRYDOCK, 726 FEET LONG AND 110 FEET WIDE, NEARLY COMPLETED.



THE CAISSON GATE OF A DRY DOCK.

fitted between the sides of the vessel and the dock to keep the boat from listing to one side or the other.

"I'd rather dock a battleship any day than a destroyer or a submarine," said Mr. Lowry, "particularly a submarine. There isn't a flat place on it anywhere."

"But how do you know just where to set the blocks?"

"We have to study the plans of the ship and lay them accordingly. We have sliding bilge blocks that we pull up against the hull after the water is pumped out, so that the keel lies on the keel-blocks. Usually the stern lies lower than the head, and as soon as it rests on the blocks we put in a pair of the after-shores. Then we pivot the vessel on them and swing the head around until it is set just right. Then we put in another pair of shores forward. If you go over to dock No. 3, you'll see the blocks we finished setting yesterday for a destroyer. A nasty job it was, too, because the propellers of the pesky little boat stick down below the keel, and we have to build up the blocks so as to keep them clear."

"But what is the gate of a dock like?"

"Hasn't any one told you that yet? It is just a boat that fits up against the end of the dock, and it is held there by a pressure of water outside. To make a tight joint a heavy strip or beading of rubber is used between the gate and the end walls of the dock. You had better come around the day after to-morrow and see the whole thing."

We were on hand on the day appointed to witness the docking of the battleship Connecticut, and were in time to

see the dock filled. Water poured in slowly until it was of the same level inside as out. The dock gate was a boat-shaped caisson, about fifteen feet wide at the top and bulging to fully twenty feet below. The bulging sides were necessary to keep it from being crushed in by the enormous pressure of the water. When the water pressure was equalized on both sides of the gate by filling the dock to sea level, water was pumped out of the interior of the caisson until it was light enough to float. Then it was towed out of the way. When everything was ready the battleship was towed up to a position before the dock. A line was run from the bow to a capstan at the head of the dock, and then a monkey engine was started and the line was very slowly taken up on a winch. On each side were gangs of men, with side lines attached to the vessel, by which they centered the ship. There were sighting lines stretched across the dock, by which the exact position of the vessel over the blocks could be determined. While the battleship was being manœuvered the caisson gate was towed back to position and sunk by admitting water into it. Then the pumps were started to clear the dock of water. As the water settled we could see the heavy rubber beading being crushed flat by the pressure of the water on the outside. In due time the entire dock was emptied of water, revealing the bare hull of the battleship resting upon the blocks that had been set for it by the master shipwright. In addition to these several sliding blocks were drawn up by chains against each side.

CHAPTER XX.

TWENTY MILES UNDER THE SEA.

"Oh, Jim, look here! If that isn't, for all the world, like a squab on a turkey platter."

It was absurd. There, at the bottom of a great big dry-dock, large enough to hold a battleship, was a saucy little submarine.

"Looks lonesome, doesn't she?" said Bill.

"Strikes me she's an independent little upstart that doesn't care a hang about company."

"She has fine lines, hasn't she?" remarked Bill. "Tapers like a fat cigar. I'll bet she can go some."

We walked around to the gang-plank that ran across to the boat from about half-way down the sloping, stepped side of the dry-dock.

"Now, if that isn't tough," I exclaimed; "the most interesting thing in the whole navy yard, and they have hung a 'No visitors' sign on it."

"Maybe they'd let representatives from the *Evening Sphere* go aboard," put in Bill. But the sentry would not listen to any excuses. He had strict orders to let no one on that boat.

"Where can we get a permit?" I asked.

"I don't believe you can get a permit anywhere, sir—par-

ticularly if you are reporters. They are installing some new machinery on that submarine, that the Department does not care to have published in the papers."

"But we promise not to publish anything without submitting it to the Department for approval. Don't you think the commandant of the yard would let us go aboard with such a promise?"

"How would he know that you would keep your promise?"

A happy thought struck me. "Suppose I ask Cousin Jack to see whether he can get us a pass. He is a lieutenant-commander in the Navy, you know."

My request to Cousin Jack went off by the very next mail. Two weeks later, when we had almost forgotten the event, I received a letter with an official seal in the corner.

"Hurray!" I shouted, slapping Bill on the back. "It's from the Bureau of Navigation of the United States Navy, and signed by the Chief of the Bureau himself. He says that we may go aboard a submarine, and, what's more, we can take a trip in one during manœuvers now being carried on off Provincetown."

A letter from Cousin Jack arrived in the same mail, and he told us that we were unusually fortunate. It was almost unheard of for any visitor to be allowed aboard a submarine during manœuvers, and that he had obtained permission for us on the condition that we would not publish a word of what we saw without first submitting it to the Department.

That very night we took a Fall River boat, and the next afternoon arrived at Provincetown. Armed with our permit, we took a steam-launch to the old monitor that was acting as "mother" for the fleet of submarines. The officer of the deck introduced us to the ensign, who commanded one of the submarines. Instead of being named like any other vessel would be, this humble little craft was designated only by a number. For instance, "E3," the letter standing for the class and the numeral for the number of that class. The submarine we were to board was moored alongside the monitor, and it was rising and falling with a gentle swell, looking like a large whale. The ensign sent for Mr. McDermott, the chief gunner's mate, and put us in his charge. He led us over the gang-plank to the narrow deck that emerged from the water. It was only five feet wide and about sixty feet long. A steel rope ran around it and served as a hand-rail. An elliptical tower rose from the deck amidships, and from the top of this projected a hood, or conning-tower, protected with heavy plate-glass windows, for observation when the craft was running awash. There was a miniature navigator's bridge for use when sailing on the surface, and in front of this were two tubes that reached to a height of over twenty feet from the deck.

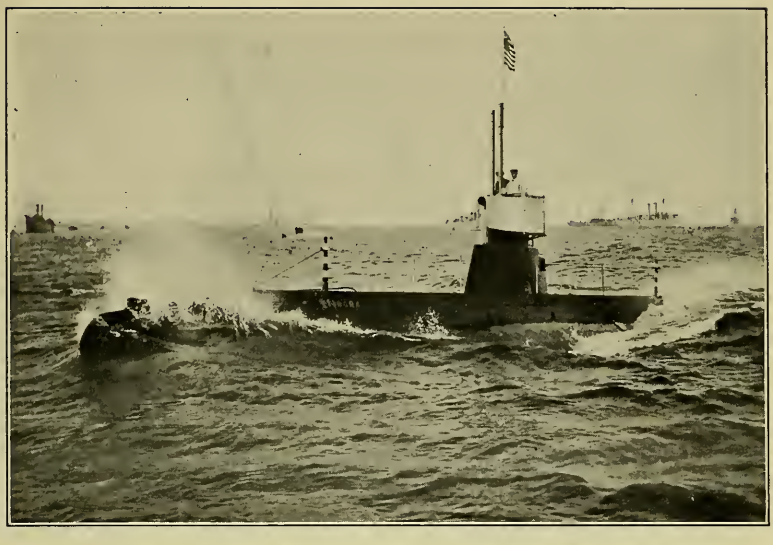
"Those are the eyes of the submarine," said our pilot. "A submarine does not wear its eyes in sockets, as we do, but on the ends of a pair of stalks, like snails or crabs."

Of course, that excited our curiosity, and we fired a broadside of questions at him. "Come down below," was

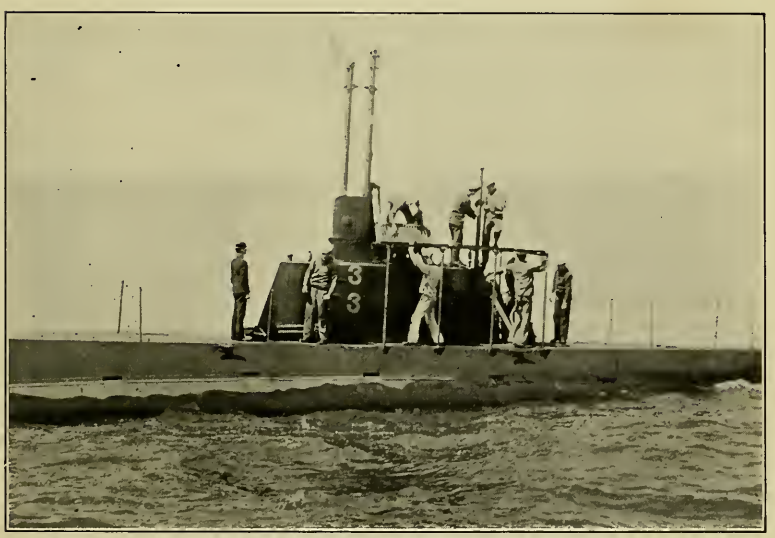
his response, "and you can see for yourselves how the eyes work. We haven't any ladies' entrance to these boats—only a hatchway."

We crawled through a manhole in the deck and down a ladder, while I wondered if there were fire exits anywhere. That hole in the roof would make an awfully tight jam in case of trouble.

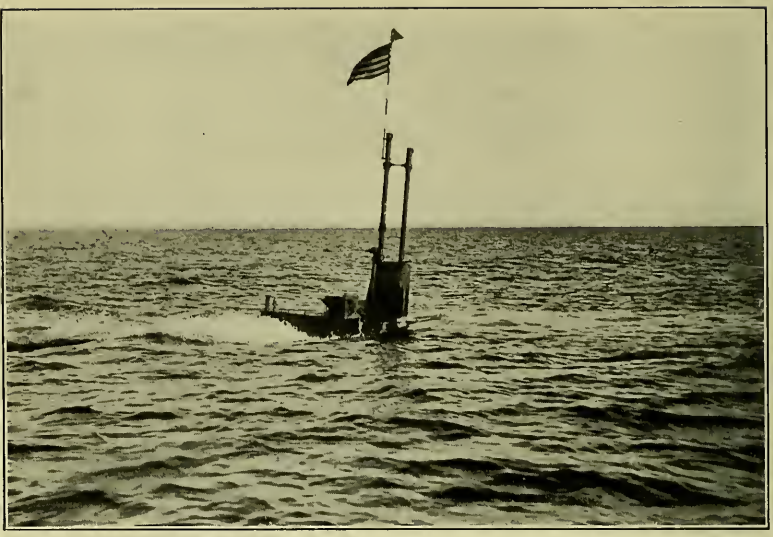
I had always imagined that the submarine was divided into separate cabins by compartments or bulkheads, and that it had an upper and lower deck; but there were no bulkheads in this boat. Mr. McDermott explained that some of the larger boats had bulkheads, but the idea of two decks was manifestly absurd in a vessel whose extreme outside diameter was only twelve feet. After taking out the space occupied by the water-ballast tanks and compressed-air reservoirs, there remained a very cramped interior. I had no idea that the boat was so small. We could not walk erect without hitting our heads against valve wheels, brackets, rods, and other projections depending from the roof. The crew habitually walked with heads ducked to avoid obstructions. We could see from end to end of the boat, as there were no partitions of any sort. It was marvelous how every nook and cranny was utilized to the fullest advantage. Although there were no partitions, the boat was evidently divided off by imaginary lines into different quarters. Just forward of the main hatchway was evidently the galley, for the walls were hung with brightly polished cooking utensils. Forward of the galley was a



SUBMARINE RUNNING AWASH.



CLEARING THE DECK BEFORE DIVING.



RUNNING WITH THE CONNING TOWER OUT OF WATER.

ALL UNDER BUT THE PERISCOPE TUBES.

table in what proved to be the captain's quarters, while at the extreme forward end of the boat, where the torpedoes were launched, there was a complicated assemblage of wheels, dials, levers, instruments, etc., that fairly dazzled one with their high polish. Aft were the gasolene engines and dynamos, and under the floor were the storage batteries. Projecting from the ceiling just forward of the hatchway were the periscopes, or, as our guide called them, the "eyes" of the boat. A system of lenses and prisms made it possible, by looking into the eyepieces here, to see out of the top of the tubes twenty-five feet above. The periscope could be turned around to bring any point of the compass into view, while a scale in the field of vision showed in what direction the periscope was turned.

"You see," explained our guide, "we can run along twenty feet under water with only this tube sticking above the surface. It is such a small object that no one would notice it, and yet we can see perfectly all around us, and manœuver the boat in absolute safety."

"But don't you ever go deeper than that? I thought you went down to the bottom of the sea."

"Where the sea is no more than two hundred feet deep we can go to the bottom; but below that the pressure grows too heavy, and eventually it would be enough to crush the boat. After all, it isn't necessary to go very deep. If we run along at a depth of sixty feet, we are sure to clear all shipping, and no one could possibly find us."

"Can you see under water?" I asked.

"No, not more than one hundred feet or so, and then very dimly, as if in a fog. When completely under water, we have to go by dead reckoning."

Just then the captain came aboard. At the word of command the gang-plank was raised, the hawsers were cast off, and the crew took up their positions. The engine was started, and we were off. Those engines certainly were interesting. Powerful little fellows they were, too. Between them they developed over 500-horse-power. Each engine drove its own propeller. We squeezed down the narrow passageway between them, and saw that the propeller-shafts passed through the electric motors which drive the vessel when completely under water. The armatures of the motors were mounted directly on the shaft, and so they revolved with the shaft when it was driven by the engines. But the circuit of the field windings was open, and no electric current was generated, so the armatures made no load on the shaft, but merely took the place of fly-wheels to steady the operation of the engines.

We climbed up through the hatchway to see what was going on without. As I stuck my head out of the manhole, I was astonished at the speed we seemed to be making. With my eye so close to the water, the waves seemed to be racing by with the speed of an express-train.

"We are making thirteen and a half knots, sir," said one man proudly.

"Only thirteen and a half," I ejaculated. "I'd have sworn it was thirty."

Just before me on the bridge was the quartermaster at the wheel.

We had no sooner taken a good look at our surroundings than orders were given to strip the upper works. The masts at each end of the boat were on hinges, and they were swung down upon the deck. The bridge was dismantled and passed in sections down the hatchway. The hand rope and the stanchions that supported it were taken down, and presently the smooth, rounded back of the submarine was bare of every obstruction except the conning-tower and the periscopes. We all crept inside, and the hatch was closed behind us. There were eighteen men besides ourselves within the hold of that tiny vessel. The gasolene engines had already been stopped, and we were now running with our electric motors. It was astonishing how quiet everything was. There was only the slight hum of the motors and the sound of the spray at our bow. The quartermaster continued navigating the craft from within the conning-tower.

"Fill the main ballast tank!" called the captain. "Fill the forward trimming tank!" A moment later, "Fill the after trimming tank!"

We could hear the water rushing into the big U-shaped tank that lay under our feet and extended part way up the walls at either side of us. The pointer of a large depth-gage told us just how fast we were sinking. When we were awash, the motors, which had been stopped while the tanks were being filled, were started again. A man was stationed

in the conning tower, and immediately below him was the look-out with his eye to the periscope. It was remarkable how stealthily we moved. Everything was quiet. There was no vibration, and absolutely no rolling or pitching.

"Why don't you run the boat with gasolene engines?" I asked the chief gunner's mate.

"Why, man alive, we haven't air enough. Those little beasts would gobble up all our air in five minutes, and then they would stop working. As a matter of fact, the engines would suffocate long before the crew. We tried that once. Everything was closed air-tight and the engines were started. They hadn't run five minutes before they stopped. But we could still breathe easily, although the sensation was not very pleasant—something like being up on a very tall mountain. So you see that the men can stand it as long as the engines can."

"Where do you get fresh air from, anyway?" asked Bill.

"Fresh air? We don't get any."

"But you have compressed air to live on, haven't you?"

"Oh, we have lots of compressed air, but we use it for other things. We don't have any other air to breathe, except what is shut up in here with us. There is enough air in this hold to last us comfortably for twelve hours, and, on a pinch, we could get along for twenty-four hours."

"Incredible!" we both exclaimed.

"Doesn't it ever make you sick?" asked Bill.

"Oh, no; this idea of having to have fresh air is all rub-

bish. I've lived with fishermen in the North Sea—fine, healthy men they are, too; none better anywhere. Yet those men would huddle down in the cabin of their boat, fairly reeking with fish and oil and tobacco, and would gather around an oil stove, with every crack and cranny of the cabin calked up, so as not to lose any of the heat, and there they'd stay until so little oxygen was left that the fire in the stove would go out and they couldn't even light their pipes. I've been down there with them. Glad to be there, too, out of the cold, and I would never notice how bad the air was while I was in it; but if I went out for a minute and then came back, it was hard to understand how that thick atmosphere, laden with vile odors, could sustain life. It isn't the lack of oxygen that bothers us down here in the submarine, but the fumes of gasolene and oil, and particularly the gases from the battery. They make a fellow dopey. I have seen fellows so far out of their heads that they would go round picking imaginary bugs off the engines; and once, last year, when we had a long run with the hatches closed, because the weather was very heavy, one of the lads—Al Curtis, his name was—lost his head completely. He started after the captain with a crowbar. The captain saw him coming and ducked behind a table. You should have seen them chasing each other around that table! Al had murder in his eye, and he fought and raved like a maniac, when three of us jumped on him from the rear, bore him to the floor and bound him. Most of the crew was laid up before we finished that run. But we don't often stay under so long."

There was a sharp command from our captain, in response to which the man in charge of the diving rudders turned a hand-wheel. The boat dipped and lurched forward. We watched the indicator hand travel slowly over the dial of the depth-gage. Five feet, ten feet, fifteen, eighteen, twenty—there we halted. We proceeded for a time at that depth below the surface. I climbed up into the conning-tower, but could see nothing but the dense green which completely covered us. However, the ends of the periscopes were well above the surface, and navigation was a simple matter. I was allowed to look through one of the submarine's eyes, and, while I was looking, the captain gave the command to dive. Presently, the water surged up over the top of the periscope, and instinctively I rose on tiptoes and drew in my breath, as if I were actually being submerged in the water. As we continued to sink, it was fascinating to watch the gage telling off the depth. At sixty-five feet below the surface we came to an even keel.

"No danger of running into any boats now," said the chief gunner's mate as he looked at the gage. I shouldn't be surprised if we were near the enemy. Very likely we are going to run under them, and fire our torpedoes from the other side."

We hurried forward to witness the operation of launching the torpedoes. The torpedoes were interesting looking objects, shaped like cigars, with blunt forward ends and fins at the rear crossing each other at right angles. They weighed two thousand pounds each. The explosive was

packed in the "war-head," or "cap," at the forward end. We were relieved to find that dummy war-heads were used for target practice, and that there were no explosives aboard. The main body of the torpedo was filled with air under high pressure, which drove the motor that ran the propeller of the torpedo. The rudders of the torpedo were kept pointed constantly in a given direction by a gyroscope.

"It is just like a top," explained our guide. "You pick up a spinning top on the palm of your hand, and watch it

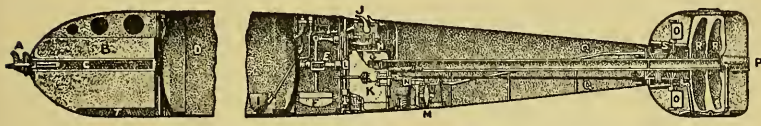


FIG. 24. LONGITUDINAL SECTION OF A TORPEDO.

A, plunger or striking rod; B, guncotton charge; C, detonating charge; D, air-flask; E, hydrostatic valve; F, pendulum. G, turbine; H, submergence control mechanism; I, superheater; J, air-lever; K, immersion servo-motor; L, pressure regulator; M, gyroscope; N, servo-motor; O, rudders for horizontal control; P, rudders for vertical control; Q, rudder controls; R, propellers; S, shaft-gearing, T, ballast.

stand upright even though you slant your hand this way and that. That's how it is with the gyroscope: its axis keeps pointing in one direction, regardless of what goes on about it. To keep the torpedo at a constant depth under water there is a rudder that is moved in one direction by a spring, and in the other by a plunger upon which the water presses. If the torpedo runs below the set depth, the water pressure will be sufficient to move the plunger up, compressing the spring and elevating the rudder. On the other hand, if it rises above a predetermined level, the water pressure is

less, and the spring forces the plunger down, depressing the rudder.

"Our boat is coming to the surface now; we will be ready to fire soon."

"Suppose we hit something," said Bill, "before the periscope is out of water."

"There *is* some danger of that, but this craft has 'ears' as well as 'eyes.'"

"Ears?"

"Yes, ears. It's all but human. On each side, there is a diaphragm like that of a telephone. These are connected by wires to a receiver. If any sound is heard, there is a way of telling whether it is louder in one instrument than in the other, and so the captain can determine where the sound is coming from. He always listens for the noise of the propellers of a vessel or the chugging of its engines before rising to the surface.

At the forward end of the boat there were four torpedo-tubes, two of which could be manipulated at a time. Our guide explained that the torpedoes would be placed in the tubes, the breach-blocks closed and then the cap at the outside opened. The nose of the boat formed the cap. By turning a hand-wheel, the cap would be moved out a trifle, letting the water run into the tubes around the torpedoes, and then the cap would be turned on its axis so as to bring two holes in it into register with two of the torpedo-tubes. There was a plate inside which would indicate when the proper registry had been obtained.

"MY, HOW ANGRY THE CAPTAIN WAS!"—See page 209.

SHOVELING GARBAGE FROM A SCOW UPON THE CONVEYOR.

The motors had been stopped for an instant, when the order came to unseat the cap and flood the tubes. Instantly our bow tipped downward, and we lunged forward. Bill and I knew there was some danger, by the look on the faces around us. We followed their gaze, and saw the indicator hand racing around to 100, 110, 120, 135 feet. By that time the engine had been started, and the man at the diving rudder-wheel brought us up so smartly that the boat leaped out of the water, betraying us to the enemy, of course.

My, how angry the captain was! He kicked up an awful row. Some one had blundered. There were no torpedoes in the tubes when the order to flood them was carried out. The nose of our submarine was suddenly loaded with several tons of water. Naturally we had gone down like a shot. I didn't realize before what a delicate balance had to be maintained in that boat. There were ballast tanks all over. First, there was the main tank, the large U-shaped reservoir at the middle of the boat that surrounded us on three sides; then there were trimming tanks fore and aft to bring us to an even keel, and finally a tank right at the center of gravity which provided a delicate adjustment of our displacement. We learned that usually the boat is weighted with water until it has a reserve buoyancy of only 500 pounds. Then it is forced down by driving it forward with the horizontal rudders tipped. When we first went down it took us about a minute and a half to reach a depth of fifteen feet, but our plunge, when the torpedo tubes were opened, was by no means so gradual.

We dived again, but this time under control, and we manœuvered about under water for half an hour or more, so that the enemy would lose all track of us. At one time we must have been directly under one of the vessels, for we could hear the churn of her propellers in the "eophone," or the "ears" of the submarine. Finally, we ventured to come up to the surface, and located the vessel we were after, about three miles away. Again we dived, and headed toward the spot. When we had arrived within striking distance, the captain manœuvered the submarine so that it would point in the proper direction, not at where the enemy then was, but at the point to which he would have traveled by the time the torpedoes reached him. The torpedo-tubes had been blown clear of water after the blunder, and had been charged with four torpedoes. The cap was turned so as to open two of the torpedo-tubes. When all was ready, the captain pulled a cord that admitted compressed air into the tubes just behind the torpedoes, and started them on their way. At the same time a lever in the tube sprang a trip on each torpedo that set the propeller motor running. The instant the torpedoes left us, our bow, relieved of their weight, which amounted to nearly two tons, sprang up, but was brought down very cleverly by the steersman, who manipulated the horizontal rudders. The other two torpedoes were then uncovered by turning the cap, and they were fired one at a time at the enemy. Then, having shot our bolts, we turned about, and beat a retreat to port.

Every one was rather subdued on account of the blunder

that had been made. "Was there really any danger?" I asked our guide.

"Well, if we had kept on, we would have struck bottom, and if the water was a couple of hundred fathoms deep, the pressure would have crushed in the boat."

"Were you ever in any serious accident?"

"No, nothing that resulted seriously.

"England, France, Germany, Russia, Italy, all of them have had terrible accidents; boats have been sunk, cut into, set on fire and exploded; but so far Uncle Sam has escaped without the loss of a single submarine," said McDermott, reaching up and rapping on a piece of wood. "It looks as though it was a little more than mere chance that saved us, though we've come mighty near trouble once or twice. I was on the Porpoise once, when I thought my time had come. We were making a test off Newport to see how near we could bring the boat to perfect equilibrium. The water was let into the tanks slowly, cutting into our reserve buoyancy until there was practically none left. We were submerged and just barely floating, when all of a sudden we found the boat was going down by the head. We couldn't check it before it had sunk to the bottom, one hundred and twenty feet below the surface. The Porpoise was not able to withstand the pressure at that depth. Compressed air was blown into her main ballast tank to force the water out, but instead of doing so the plating of the vessel began to leak, and water began to come into the boat. There we were, trapped, nose-down into the mud, with one hundred

and twenty feet of black water overhead, squeezing us in its cruel grip with a pressure of three and one-half tons on every square foot. We could have stayed under twenty-four hours if necessary, and waited for help, if only the boat did not leak; but its seams were starting already, and letting in the salt water. That's the one thing we dread most in these boats. If the salt water reached the electric batteries, we were done for. The fumes of poisonous chlorine gas would pour out, and we would be put to sleep in a few minutes. With death staring us in the face, you can just bet we worked the handpumps for all we were worth, taking turns every few minutes so as to bring fresh muscles into the contest. My, how we did pump! The leaks were growing so bad that we could make but little impression, but we kept plugging away. There was nothing else to do. After a time—I don't know just how long, it seemed years—we began to gain slowly on the water. The bow of the Porpoise began to lift. That encouraged us to put forth still greater effort, and slowly but surely the water was driven out of the ballast tank until the gauge showed that we had one hundred pounds buoyancy. The nose of our boat had been lifted out of the mud. Then our diving rudders were slanted up, and the electric motors were started, sending us up to the surface in a jiffy. The men up above didn't know what had happened. They said we had been under three-quarters of an hour, and they were beginning to grow much excited. That's the closest shave I ever had. In fact, I think it was the nearest thing to a real submarine accident

we have ever had in the United States Navy, and I hope I never have to go through anything like it again."

"Well, it was a closer shave than I would care for," said I.

We were rapidly heading back to port now. It had been a great trip, and we had enjoyed it immensely, particularly the accident, so long as it had not resulted seriously. It added a thrill to our experiences that I could put in my story for the *Sphere*. It was a fine story, I know. There was lots of exciting interest in it. Bill went over it with me and strengthened the weak points. I am sure it was the best article yet, but after reading it over for the fifth time, it occurred to me that it wasn't a very honorable thing to do, this making capital out of the blunders of others. It was not very patriotic, either, to tell the world of this lapse on the part of one of our men. "It seems like 'snitching,' " I said to Bill.

"I don't know but you're right, Jim. Suppose we cut out that part about the involuntary dive, particularly as we have to send the article to the Navy Department before it is published."

And so it happened that no mention of the accident appeared in the columns of the *Sphere*.

CHAPTER XXI.

MAKING SOAP FROM GARBAGE.

It must not be supposed that, all this time, we refrained from taking in the amusements and shore resorts about the city. We took in all the sights from one end of Greater New York to the other, but I must admit that we found fully as much fun in studying the big engineering undertakings about the city as we did in Coney Island, although, of course, it was a totally different kind of fun—a more satisfying kind. All the time we were on the watch for good stories for the *Sphere*. Most of our experiences were far from exciting, and certainly not worth recording here. Bill always had his sketch book and camera along to add interest to the stories. Among the various topics we wrote upon were the power stations in Manhattan and Brooklyn, the fire department of the city, the sewage system, street cleaning and disposal of garbage and ashes. This last topic we found exceedingly interesting. For instance, we discovered that there were more than thirteen hundred miles of streets in New York that had to be kept clean, and there was an army of sixty-five hundred men employed to sweep these streets and keep them free of refuse. If all the garbage and ashes and street sweepings in the entire city were dumped into Broadway in a single year's time, the street would be

buried all the way from Bowling Green to Twenty-third Street, a distance of two miles, to a depth of a hundred feet. We got our facts from the Street Cleaning Department. We even went up with one of the scows to Riker's Island, and saw them unloading the stuff and making new land with it. It is astonishing what a variety of materials there was in that ashes. Old mattresses and bed springs were the bulkiest objects. Then there were paper boxes, rags, old dresses and hats, rubber, tin cans, bottles, and a hundred and one things. Of course, only materials from the ash cans and the street sweepings were used in this way. It would not do to make land with garbage or any material subject to decay.

"Out in the country," said the street cleaning official who was showing us around, "garbage is fed to the pigs and the farmer gets it all back in the shape of pork and bacon. Unfortunately, we cannot get hogs enough to eat up the hundreds of tons of garbage that come from New York's hundreds of thousands of kitchens every day. We used to load the stuff in barges and dump it far out at sea, but the sea instead of swallowing the stuff, would cast it up on the shores of the summer resorts. Then we tried burning the garbage, but it is an expensive job and we haven't made a success of it yet. Now we dispose of the stuff to a plant that turns it into soap."

"Soap," I exclaimed, "soap out of garbage!"

"Well, not exactly that. They get oil out of it and sell the oil to soap manufacturers, and what's more, you have

surely used some of the soap, for it is one of the most popular brands in the country."

That was interesting indeed, and I could see a good story for the *Sphere* in it. It would be great to stay by a scow of garbage, following it from the dumps to the plant, and then follow the material through the plant to the point where the oil was extracted from it. We had to get a permit from the main office of the plant.

The next evening after dark found us aboard a tug towing a string of three barges down the river. The towing is always done after dark in summer time, out of deference to the people at the shore resorts who do not like the sight and smell of the garbage scows. The smell, by the way, was not unendurable. Of course, they were not rose gardens, by any means, but the garbage was well sprinkled with chloride of lime, which killed most of the odors. At any rate, we didn't mind the smell very much.

It was a long, weary night, particularly after eleven, when we had passed through the Narrows and out into the lower bay. The moon had sunk behind the Staten Island hills, and a heavy fog settled down upon us, so that we could see absolutely nothing out upon the water. Even the lights on the scows behind us were hidden from view. Under the circumstances, there was nothing to do but stop and wait for better weather. The engines of the tug ceased their pounding, and we lay to, listening for warning signals. The tide was low, and we would have to wait a couple of hours anyway before we could enter Jamaica Bay and run up the

channel to Barren Island, where the garbage plant was located. We listened intently for other fog-bound craft. Off to the right we could hear a bell buoy tolling dolefully, and the fog horn of a lighthouse blaring forth periodically. After a time, we heard the approach of a vessel that was tooting its whistle at regular intervals. Presently we heard the churn of its paddle wheels, and the rag-time music of a string band. Then very unexpectedly there loomed up out of the fog a belated Coney Island steamer, headed directly for us. There was intense excitement for a few minutes, with much shouting and some screaming, but the excursion boat backed away from us in safety, only to come within an ace of striking one of the garbage scows.

"Holy mackerel!" I heard one man exclaim, "what a death! There's garbage and swill on every side."

There was much merriment at our expense, until the excursion boat drifted away in the fog out of sight and hearing. That was the nearest approach to excitement that we had that night. Now and then we would hear the whistle of a vessel, but nothing came in sight. After a while we grew tired and lay down to sleep. I was awakened just before dawn to find that we had reached the island and were docking our barges. Five other barges had arrived just after we did, making a string of eight heavily-loaded scows, twenty-one hundred tons in all. It certainly would take an army of hogs to devour that stuff every day!

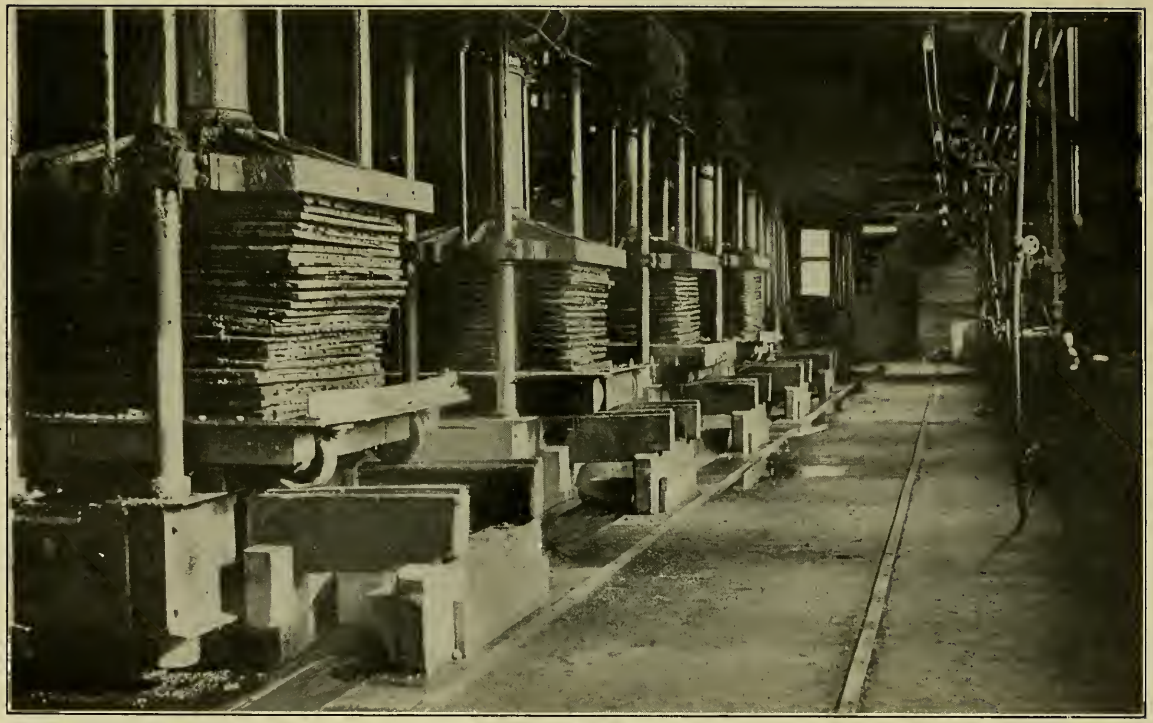
The tug put us ashore, where we had to wait an hour before the six o'clock whistle blew and work in the big plant

started up. The garbage was taken out of the scows, and up into the plant on endless conveyers. A trough was dropped down on the scow, and this led up to the plant. Over this trough an endless chain travelled. The chain was shaped like a rope ladder, with metal blades in place of rungs. A gang of Italians shovelled the garbage upon the trough, and the blades pulled the stuff along until it reached the end of the trough, where it dropped into another conveyer that carried it on up into the building. I saw one of the Italians pick up something out of the garbage and wipe it on his shirt sleeve. It was a silver bread knife. He bit it to see if it was the real thing, and then put it in a pot at his feet. Then I noticed that all the men had treasure pots ready for such prizes as they could pick up, and they were watching the garbage like hawks, hoping to profit by the carelessness of the householder. Several prizes were picked up during the morning, but they were mostly plated forks and spoons.

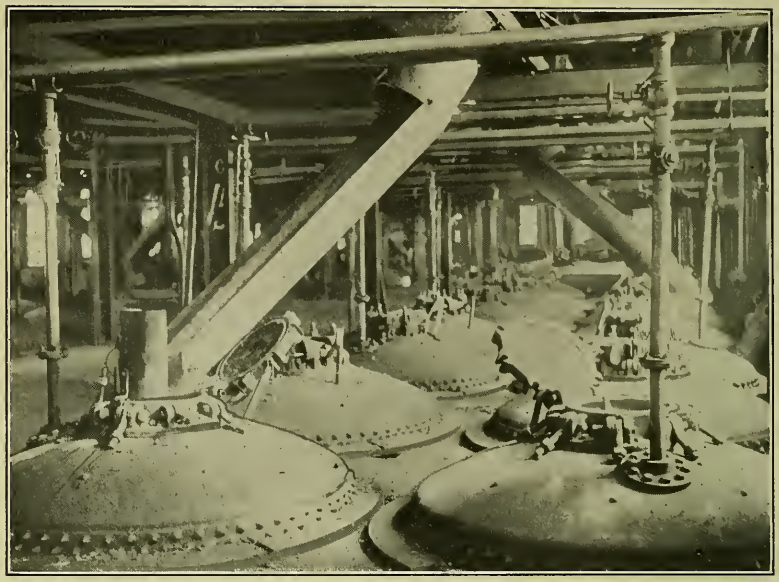
"Last year," said the chief engineer of the works, "one of the men found a ring with three large diamonds in it."

"How in the world did such a thing get into the garbage," we asked.

"Oh, I don't know," he said, "maybe Madam took off her ring and laid it on the kitchen table while she washed her hands and then forgot all about it. The maid may have swept the crumbs and scraps off the table into the garbage can without noticing that the ring was among them. Then I suppose the girl was fired for stealing her mistress's ring."



HYDRAULIC PRESSES SQUEEZING THE JUICES OUT OF THE BOILED GARBAGE.



THE DIGESTERS IN WHICH THE GARBAGE IS COOKED.

THE DRY RESIDUE USED FOR FERTILIZER.

"But didn't you return the ring?" asked Bill.

"Oh, no, we couldn't attempt to do that. It would be too hard to locate the owner. We always let the men keep what they find. At this time of the year," he went on, "we frequently get fruit that has been condemned by the carload, but by no means is all of it bad, and then the men have a feast. But we never let them carry the stuff off the premises, so that there is no danger of re-selling any fruit to the public once it has found its way into the garbage pile."

The conveyor passed through a low shed in which were several boys watching the garbage as it travelled by them and picking out all the tin cans and bottles they could see.

"If we could only get people to stop throwing such stuff into the garbage cans," said the superintendent with a sigh, "our bills for repairs would be cut in two. The tin cans, we find, are turned into sash weights and the bottles are sorted out. Those with the name blown in the glass are sold back to the owners, but the others are sent to glass manufacturers, who melt them up into new glass bottles."

On entering the main building, the garbage was dumped into huge boilers and cooked for ten hours by letting in steam in direct contact with it. At the end of that time, the stuff was reduced to a sort of thick brown soup which had a peculiar sweetish odor like burnt molasses, I thought; but Mr. Brown said it had the "fragrance of caramel and coffee." "Fragrance," mind you! How could such a word be applied to that stuff? True, the odor was not really bad at first, but its association with garbage disgusted us and the

persistence of it sickened us. We couldn't get away from it anywhere. It grew upon us so that before we left the island we were nearly overcome with nausea.

But to return to the garbage soup, it was put in large hydraulic presses to squeeze the juices out. A quantity of the steaming mass was dumped upon a piece of burlap. Then the four sides of the burlap were folded over the garbage and a frame of wooden slats was placed on top. Over this another piece of burlap was laid to receive the next charge of garbage. After a dozen or more of the burlap bags were filled the whole tier was placed under the press and squeezed for hours, while the thick brown liquor oozed out and poured through pipes to the separating vats.

"I suppose most of that water comes from the steam," I ventured.

"Some of it, yes. But there is an astonishing lot of water in garbage. Out of a hundred pounds of garbage, not thirty pounds is solid. All the rest is water with maybe two or three pounds of oil. It is that two pounds of oil that we are after."

"But how does it happen that the garbage is so wet?"

"Why, my dear boy, don't you know that the fruits and vegetables are nearly all water. You would think that milk is about our wettest food, but there is more water in cucumbers, or turnips, or strawberries than in milk. When your mother buys a pound of beef, litttle does she think that fully three-quarters of her purchase is water. Even flour has water in it. Ordinary wheat flour is twelve per cent.

water, and when it is made into bread it is nearly half water. You would hardly think now, would you, that there is more water in cucumbers than in grapes, but grapes have no more water in them than apples have, while cucumbers are nearly all water. If you analyze a cucumber you will find that it contains ninety-five per cent. of water, while milk has only eighty-six per cent. water, and grapes only eighty per cent. So you see there is plenty of water in garbage."

Bill nudged me. "Good stuff for the article," he said, and I jotted down the figures in my note-book.

The material that came from the presses seemed perfectly dry, but Mr. Brown told us that there was still some oil in the stuff, which they extracted by dissolving it with naphtha and then distilling the naphtha.

Out in the evaporating room there was an electric pump that sucked the oil off the surface of the water and there were men there with long handled scoops to skim off the oil that the pump failed to get. The dry stuff that came from the presses was put in large cylindrical screens and revolved slowly to sift out the finer particles. The sifted material was sold to the fertilizer manufacturers to be mixed with fertilizer materials, and they in turn sold it to the farmers. "And so you get back on your table, in fruit and vegetables, the nutriment that is thrown away in the garbage cans in New York," said Mr. Brown. "But there is one very funny thing about the stuff that is thrown into the garbage. It is supposed to consist of nothing but food remnants, meat, vegetable and fruit refuse. But we get everything. Look

at that cylinder there. It has been put out of commission and is laid aside for repairs."

We looked it over curiously. It was fairly bristling with wires. "Whatever did that?" we inquired.

"Don't you recognize them?" asked Mr. Brown. "They are hair pins."

"Hair pins!"

"Yes, there are thousands of hair pins thrown into those garbage cans. They won't pass through the screen, because they are doubled over. One leg goes through one hole, and the other through another, and there they are caught. It does not take long to clog up a cylinder with hair pins, and then all you can do is to go over them with wire clippers and snip them off by hand."

Our course through the factory brought us back to the scows. Several of them had been unloaded and they were being scrubbed and whitewashed.

"We do that every day or they would soon smell so badly that we wouldn't dare tow them down the bay," Mr. Brown explained.

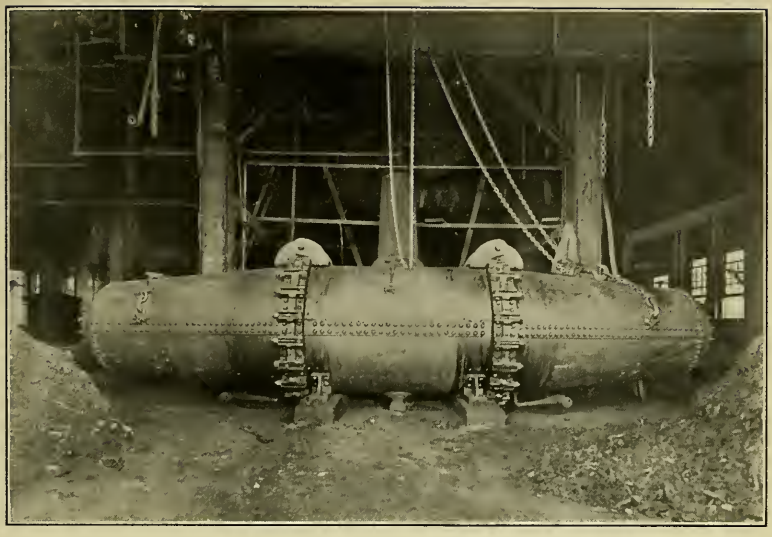
"Oh, there comes a steamboat," exclaimed Bill. "Does it stop here?"

"Yes, if you signal for it."

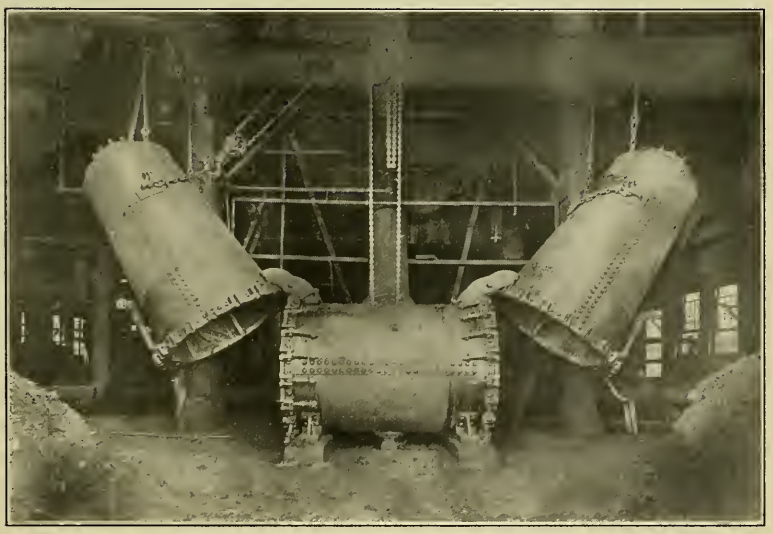
"Come on then, Jim, I am going aboard."

"But where does it run to?" I inquired.

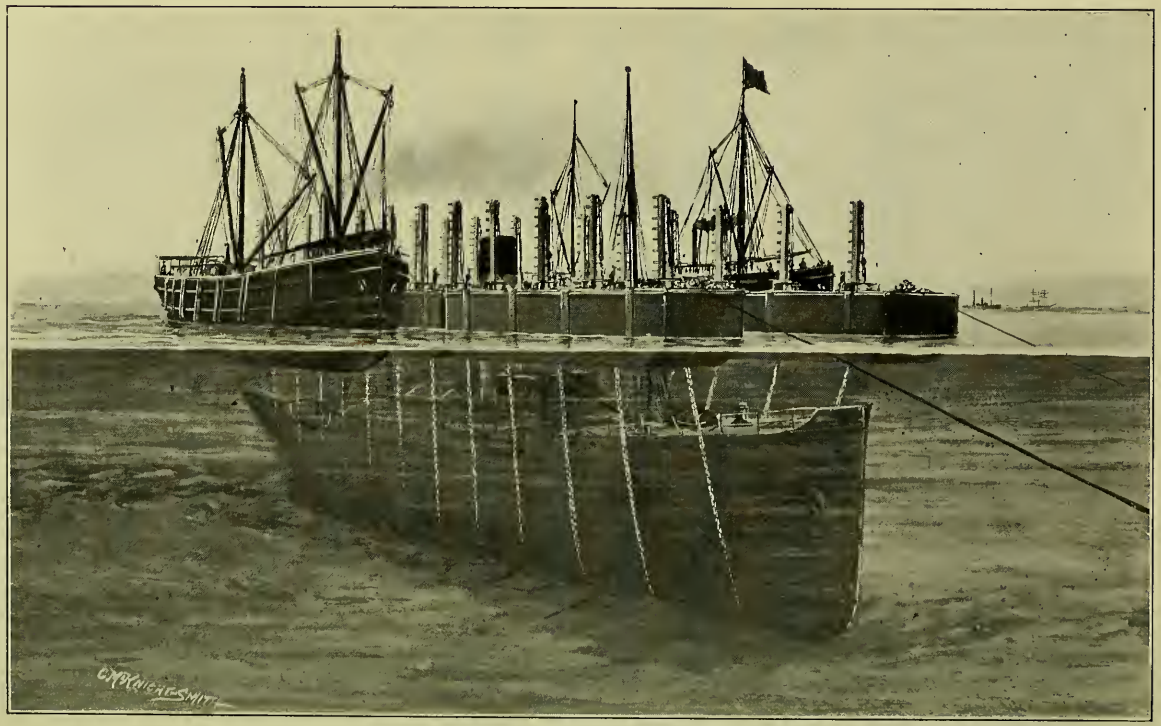
"I don't know, I have got to get away. You'll excuse us, Mr. Brown, but this sickening smell is too much for me. You have been awfully good to show us around."



STEAM PRESS FOR EXTRACTING THE JUICES FROM THE GARBAGE.



STEAM PRESS OPENED FOR REMOVAL OF THE DRY RESIDUE.



HOW THE WRECK WAS RAISED BY PASSING CHAINS UNDER IT.

Mr. Brown laughed good naturedly as Bill ran off to signal to the boat. "I stay here, day in and day out, and never notice the odor. You can get used to anything, you know."

"I didn't mind it when I first landed," I said; "but it is such a sickish sweet smell that it nauseates me. I'll be just as glad as Bill to get away from here."

The persistence of that odor was most remarkable. It stayed by us for days. Everything we ate seemed to be tainted with sickish odor of boiled garbage.

When I turned in my story to the *Evening Sphere* the Editor suggested that I follow it up with an account of another plant on Barren Island where carcasses of dead animals are disposed of; but nothing could induce us to go again within a mile of that spot.

CHAPTER XXII.

CAUGHT IN THE JAWS OF A BUCKET DREDGE.

A fruit steamer lay at her dock in the East River taking on a cargo of case oil and gasoline when a serious fire broke out. To prevent the fire from spreading to the dock and other shipping the steamer was towed out into the stream. The fire boats pumped such a deluge of water into the vessel that it sank off shore in thirty-eight feet of water.

The wreck could not have been sunk in a more unfavorable position. The bottom on which it lay was covered with boulders, which at that point formed a pocket about eight feet deep. This meant that the vessel would have to be raised at least ten feet before it could be towed to a position more favorable for wrecking operations. It lay right in the path of shipping, and at a point where the tides were so strong that work was limited to the periods of slack water at high and low tides.

This fire occurred early in the spring, but it was well toward the end of the summer before the work of raising the vessel, pumping it out, and delivering it to the owners was completed.

One day, as we were crossing the Brooklyn Bridge, we saw a smoke stack and a couple of short masts sticking out of the water while a couple of barges and several odd-looking boats were grouped around them.

"It's a wreck, Jim," exclaimed Bill, excitedly; "and they are trying to raise it."

"Yes, and we must get over there and see how they are going about it."

We found a man on South Street who, for a small sum, was willing to take us over to the barges in a launch. The visit proved well worth while. The wrecking outfit con-

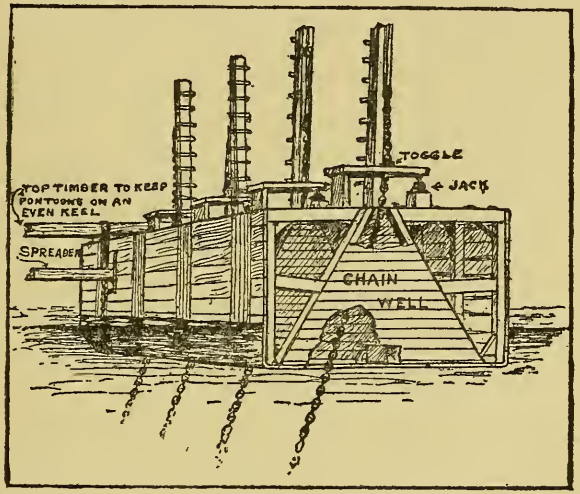


FIG. 25. A PONTOON CUT AWAY TO SHOW THE CHAIN WELL.

sisted of six pontoons, three on each side of the sunken vessel, and two steam barges, the latter furnishing the steam for the pumps on the pontoons. The pontoons were provided with chain wells, of the form shown partly broken away in Figure 25. The wells were of flat, triangular form flaring out at the bottom, which was open to the water, so as to allow for the sweep of the chain. There were four such wells to each pontoon, and the chains passed from the

pontoons on one side of the vessel under the hull and through the pontoons on the other side. Beside each chain well a short mast was provided with fall and tackle by which the slack of the chain could be taken up. The chains as they emerged from the wells passed through planks fulcrumed at one end and arranged to be lifted by hydraulic jacks at the other end. The chains after being drawn up taut by the tackle were fastened to the planks by means of

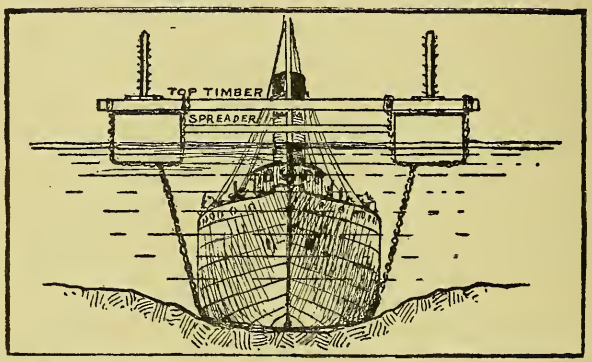


FIG. 26. HOW THE CHAINS WERE PASSED UNDER THE WRECK.

toggles or U-shaped pins fitted under the chain links, and then the hydraulic jacks were operated to raise the planks so that all the chains would pull evenly and alike.

As the pull of the wreck on the chains would tend to draw the pontoons together they were kept at the proper distance apart by means of beams known as "spreaders." There were also top timbers that ran across the wreck from pontoon to pontoon, and were fastened to the pontoons by means of chains that passed around their hulls as shown in

Figure 26. This served to keep the pontoons on an even keel.

Had the vessel rested on a soft bottom it would have been a simple matter for divers to pass the chains under it. The chains could have been lowered under the bow and then worked back and forth until they reached the desired position, but as the wreck rested on boulders such a course was impossible. It was essential to get the chains under at fixed points opposite the chain wells on the pontoons, and this made it necessary to blast channels under the wreck through which small chains could at first be passed and then be used to force the heavier chains through. The divers could not work at the bottom when the tide was running, as it was strong enough to sweep them off their feet. In the short intervals of slack water but little could be accomplished, and so the work dragged on month after month.

"We had her already to move yesterday," said one of the men. "She was coming up fine with the tide when a tug came by and kicked up such a swell that two of our chains snapped; and then we had to do all of our work over again."

"What do you mean about the tide raising her? I thought you lifted it with the hydraulic jacks."

"Oh no, we couldn't do that, it would be too hard to keep all the chains pulling alike. It is much easier to let the tide do the work for us. At slack tide we let water into the pontoons until they sink as far as practicable. Then we take up all the slack in the chain and work the hydraulic jacks so that each chain does its share of the work. If too much

weight came on one chain it would snap in two, but if we divide up the weight between them evenly they are plenty strong enough for the job."

"I suppose you use instruments to measure the pull on each chain so as to be sure that it is not too great?" I ventured.

"Instruments," he grunted contemptuously. "No. Judgment—practical judgment based on years of experience in wrecking. What's the use of bothering with instruments when I can tell at a glance just how each chain is pulling.

"After the chains are all adjusted," he continued, "we pump out the pontoon and up comes the ship, but not as far as we should like because she is lying in a sort of pocket, so we wait for the tide to lift her some more. She was just high enough to clear the pocket yesterday when that pesky old tug came along and started her to rocking. That put the chains to an awful strain, and then she pounded on a boulder and crushed two of the chains."

"But what are you going to do when you clear the pocket?" Bill asked.

"Tow her off to shallower water until she grounds, then at next slack water get a lower hold on her and tow her off again. When we get her where her decks are clear we will close all the ports, pump the boat dry, and float her to a dry dock where she can be fixed up as good as new."

Off at one side of the barge there was a large box with a couple of big hand wheels mounted at each side, which two men were turning. From the box a black rubber hose led

down into the water. We realized that this was the pump that was feeding air to a diver in the black water below. Over the rail leaned a man holding a rope. He was very intent upon his business, and somehow we didn't feel like questioning him. As we watched, there were several jerks on the line. Then the man at the rail began to haul up the rope slowly.

"What's he doing?" we inquired.

"Haulin' up a diver," was the terse reply of one of the men at the pump.

"Don't they swim up?" I asked. "They used to tell me that a diver kicks off his lead shoes and floats right up to the surface."

The fellow grunted. "What's the use of losing a pair of shoes every time he comes up?"

While we were talking a brass dome emerged from the water, and presently the diver dragged himself heavily up the ladder and aboard the barge. A curious looking object he was. We had seen pictures of divers before, but never a real live one, and we ran over to inspect him more closely. The heavy rubber suit inflated with air made him look enormously fat, while his hands, which were beefy red because they were squeezed so tightly by the wrist bands of his suit, seemed disproportionately small. His feet were encased in heavy leaden-soled shoes, and around his waist he carried a lead-weighted belt, but the oddest thing was the big brass helmet with the three little round windows in it.

The tender unscrewed the little window or face plate in the front of the helmet, then he removed the heavy belt and shoes, unscrewed the thumb screws that held the helmet down to a shoulder plate on the diver's suit and lifted the helmet off his head. The face that greeted us, small, thin and topped with a brush of fiery red hair, was all out of keeping with our notions of what a diver ought to look like.

"Aren't you going down again?" I asked him, by way of introducing conversation.

"Not now, the tide is too strong," he said as the tender undid the gasket around his shoulders and began to pull off the rubber suit. The suit had only one entrance—that at the neck.

"Say Bill," I whispered, "how would you like to try it?"

"It would be great. I wonder if they would let us."

"It would make a fine story for the *Sphere*. We shall have to work it somehow."

The diver sat down on a box, pulled out a clay pipe and filled it with strong, black tobacco, lighted it, and settled back comfortably in a cloud of evil smelling smoke. We saw that he was in a mood to talk, and so we began to ply him with questions. He had some wild yarns to recount about his own experiences, and those of his fellow divers. He told about a man who had gone down to repair a leak in a dam and had been sucked into the hole himself and held there by the pressure of the water. Try as they would, they couldn't get him out before he died a lingering death. He told about divers who had perished because their air

pipes were jammed or cut, of men who had been injured by falling objects, of men whose air valves had stuck and their suits had become so greatly inflated that they had bobbed up to the surface like cork, much to their discomfort, because it is necessary to come up slowly and adjust oneself to the change of air pressure, just as when coming out of a caisson. There were so many accidents that might happen to a diver that we began to think it might not be such a lark to try it after all.

Some of his stories were quite remarkable, especially two adventures which had taken place right there in the East River. He was working on a job one day when he was called over by an excited man who said that a diver had gone down into a sewer, and had failed to answer any signals. Our narrator told how he went down into the river and had entered that sewer which was so inky black that he couldn't see a thing, how he had groped along the other fellow's life line and finally stumbled across him lying prone on his back. He signaled to him, in the diver's usual way, by slapping his helmet, and the man apparently was conscious because he replied to the signal, but when he urged him to come on out he couldn't make the fellow budge. After awhile the fellow was induced to start for the entrance to the tunnel, but only took a few steps before he balked, sat down again and refused to move. Our man was a small one and unable to drag the big husky Scandinavian lying at his feet, so he returned to the surface. Everyone was in a quandary as to what should be done, but while they were talking it over the

signal came from below to haul on the life line, and the man was pulled to the surface. When he was questioned as to what was the matter he couldn't give a very clear account of things. He said he had seemed dazed down below and couldn't quite remember things. Then it was discovered that he had filled up with whiskey before descending into the sewer, and that while under pressure the whiskey took effect, making him dead drunk, although he was perfectly sober when he started down, and on his return to the surface.

The other experience referred to made a very thrilling yarn, and I am not sure that it wasn't all pure fiction, although a number of men who have had much to do with divers have assured me that it was by no means an impossible adventure.

Our narrator began his story with the following question: "This water looks purty dirty around here, don't it?"

"It certainly does," agreed Bill.

"Well now, why shouldn't it? Look at all the sewers that empty into it year in and year out, and the stuff ain't got no chance of gettin' away."

"But doesn't the river carry it out to the sea?"

"What river?"

"This river. This is the East River, isn't it?"

"This ain't no river. It's nothin' but a channel connectin' Long Island Sound with New York Bay."

"But don't the tides carry the stuff off?"

"Tides nothin'. They had a float here this summer and kep' track of it night and day. It traveled one hundred and

eight miles in three days, and when they picked it up it wa'n't a mile from where it started. So you see how much the tide clears out these waters.

"Well, as I was sayin', this water gets so full of stuff out of them sewers that they has to dredge out the slips every once in a while. There is a power house over there where you see them chimneys and they takes in water from the river for their condensers. The water is so foul and choked up their intake so frequent that they decided the only thing to do was to put in another intake. I was down there last year on the job of cutting through a concrete wall."

"How could you do that under water?"

"Oh, I had an air drill and——"

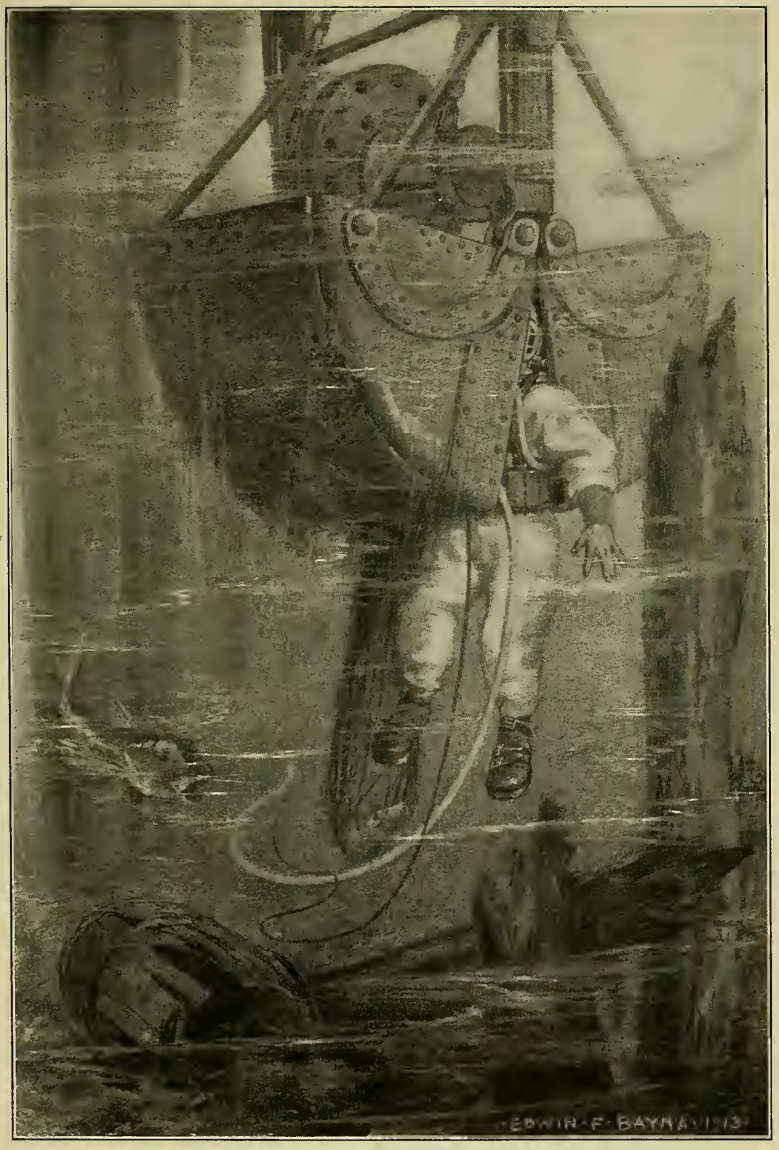
"But can you work an air drill under water?"

"Oh, yes, we run the exhaust pipe up to the surface so it don't choke with water. I drilled a row of holes through the concrete and then split it off with a ram. On the other side of the dock they was doin' some dredging."

"A suction dredge, I suppose," volunteered Bill.

"Naw. They don't use them around here. This was a clam shell dredge. You've seen 'em, ain't ye. The bucket is like two clam shells, wide open when it goes down, and then when it strikes bottom they spring a trigger and the shells snap shut and take a big bite out of the mud. Well, they had stopped dredging for a bit and when I was down below it struck me I'd like to see how they was gettin' along with the work, so I strolled over between the piles. It was

purty dark down there, and I couldn't see more than a few feet ahead. If the dredge had been workin' the water would have been so riled I couldn't ha' seen a foot. Well, I stood there leanin' against a broken-off pile, resting a bit, and trying to see what there was to see. I must have set there quite a spell musin' and dreamin', when all of a sudden a great big black thing come down over me. By gracious! I thought it was a whale! Before I had time to think it had me in its mouth and was liftin' me off my feet. It had a grip around my waist. My! how it bit. I thought I would be cut in two. Then I found the broken pile was caught in the jaws with me, and that was all that saved me. I couldn't see a thing, everything was as black as night. The water was all riled up. Then I heard the rattle of machinery, and I knew that it was a clam shell bucket as had me. It was the greatest bit of luck that the pile was picked up with me, but in another minute my hose would be torn off and then I'd smother in the black mud that was pouring down over me. I was saying my prayers and kicking my feet for all I was worth when I come up to the surface. I could see out between the jaws of the bucket that I was out of water, and I kept my feet going so as to attract attention. 'Now they're swinging you over the scow,' I sez, 'and then they'll dump you in and you'll be drowned in the mud.' I could feel the hose tightening up, and she was just ready to break when the bucket begun to go down, not in the scow, but back into the water again. Then 'fore I knew it the jaws opened and I fell gaspin', and pretty sore



"IT HAD ME IN ITS MOUTH AND WAS LIFTIN' ME OFF MY FEET."—See page 234.

A MAZE OF SAFETY DEVICES ON THE DISTRIBUTING FRAME.

around my waist. 'Cheer up, old man,' I sez; 'you're not dead yet,' and I begun to crawl. I didn't dare give a pull on the life line for fear they might begin to haul me in and catch my hose somewheres in the piles, so I just groped along, using the line as a guide, and made my way back. Then I laid down to rest a bit and after a while—it seemed like hours but it couldn't ha' been more 'n a minute or two —I woke up! 'Tim,' I sez, 'you've been dreamin'. You was never picked up by a dredge or you wouldn't be alive now.' 'Go on,' I answers, 'if that wa'n't a dredge, what gave you such a sore stummick?' It took me a long time to crawl back to the other side of the dock and then I gave 'em the signal to pull me up. Gee, but I was glad to see daylight. When I got up on the dock the man in charge of the dredge was there. 'Say, old man,' he sez to me, 'you had a narrer escape, that time,' he says; 'but you're some kicker, you are. Ef you hadn't kep' your legs amoving I would never ha' seen ye and lowered ye down, but don't trespass on my property again,' he sez. 'No danger,' sez I.

"I took an hour to rest before going down again."

"You don't mean to say you went down again, that day," I gasped.

"Sure, why not? My tender give me a good rub-down, and then I was all right."

"Say, could I go down in a diving suit?" I ventured.

"You?" His grin piqued me.

"I am not afraid."

"You may think different when you get the helmet on."

"He's game," put in Bill in my behalf. "Shall I get the suit?"

"What, now, in this tide? Look here, sonny, I come up 'cause the tide was runnin' too strong. Besides it's about forty foot deep here, and that's a little too much for a starter."

"But," I pleaded, "I don't have to go all the way to the bottom. Can't I land on the wreck instead?"

"Not till slack water, anyway."

"When will that be?"

"In about four hours."

"Can I then?"

"We'll see how your nerve holds out."

Four hours is a long time to keep up one's nerve. Mine was ebbing fast when in the afternoon we returned to the barge, but I put on a brave front and didn't let anyone know how I really felt.

It was Tim's suit that I put on. I have already described the suit, but I was astonished to find how heavy the leaden shoes were. I could hardly move with those weights on my feet. But I had to walk to the side of the barge, climb down a ladder, and lean over the gunwale while they strapped the leaden belt around my waist. It weighed eighty pounds, and I had still to carry the weight of the brass helmet. When the helmet was put over my head, the face glass was out so that I was able to breathe naturally and talk to Bill and the tender while the corselet was being fastened down with thumb screws.

"Now, sonny, how's your nerve?" Tim asked me, with a grin."

It was just about gone, but I gritted my teeth and answered "All right. How long are you going to let me stay down?"

"It's up to you, we'll haul you up when you give us the signal," and he started screwing in the face plate.

"But what is the signal?" I gasped. He didn't hear me. I clutched at his hand, and made it evident that I was not ready to be bottled up yet.

"I thought you'd lose your nerve," laughed Tim as he removed the face plate.

"No, I haven't," I snapped, "but how am I going to signal to you if I don't know the signals?"

"Don't you know them?" and he proceeded to explain the diver's signal language.

"Hold on," I interrupted, "there is only one signal I need. What do you do when you want to come up."

"Three jerks on the life line."

"All right, clap on the face plate then."

The face plate was screwed on tight and the pumps were started. I could hear the roar of inrushing air, pulsating slowly with each stroke of the piston. I was at the mercy of the pump now. I could feel my suit fill out with air. With difficulty I made my way down the ladder into the black oily water, but I grew lighter as I went down. In another minute I was immersed. The ladder ended abruptly. My groping foot could find no other rung. I thought the

ladder went all the way to the deck of the wreck, but evidently I was wrong. There was nothing to do but jump off. I lowered myself down hanging to the last rung with both hands, then I let go and dropped gently on the deck of the vessel.

It wasn't such a bad experience so far. I couldn't see more than a few feet about me because the water was so muddy. I felt as if I were in a caisson. As a matter of fact I was in a caisson made of rubber instead of wood or concrete. The air I had to breathe was that which filled my suit. At the back of the helmet there was a valve which let the air in from the pumps above, and at the side, one that let the air out when it exceeded a certain pressure, for which the valve had been previously set by the tender. As long as nothing happened to these valves I need have no qualms, but if they should be clogged I might have a very unpleasant adventure. I was a little afraid to move at first for fear of kinking the air hose and cutting off my supply, but I felt of it and found that it was very stiff and not liable to get into trouble under ordinary conditions. Another thing I was afraid of was that a projecting nail or some sharp point might cut through my rubber suit and rob me of my precious air.

Well, here I was on the deck of the ship unable to see anything to speak of. What was I going to do? It occurred to me that it would be a good plan to grope around until I could find some object that I might bring up as a souvenir of the trip. Accordingly I began to creep along the deck

feeling my way like a blind man. Once when I looked up I noticed a string of silver beads which seemed to be caught under a projecting ledge. But they were merely air bubbles from my own helmet that had lodged there. As I became more accustomed to the darkness I saw something under a board that looked like a brass pipe. May be it was a telescope. It would be just the thing for me, but it was tightly wedged under the plank. I worked away at the board trying to pry it off the object, when suddenly something toppled over and the plank shot up to the surface with me clinging to it.

That was rather an ignominious ending to my first and only experience in a diving suit. I had meant to come up in approved style after giving the proper signal. But the men hauled me to the barge when they saw me come to the surface and helped me out of my suit. The sudden change of pressure I had undergone in rising so quickly from the deck of the vessel to the surface pained my ears.

"It's lucky for you," said Tim, "that your air pipe or life line wa'n't tangled when you come up. I've known of more 'n one person who has been caught that way. Once I was caught with my head down and so much air was pumped into my suit that my pantlegs filled out like balloons, and there I stayed. I had to signal cautiously for slack on the rope and the air pipe till my feet stuck out of the water and the tender seen me and come to get me in a row boat.

CHAPTER XXIII.

THOUSANDS TALKING AT ONCE.

THE subway was run down lower Broadway by the cut-and-cover method—that is, at night, when there was little or no traffic, the street pavement was ripped up, and in its place was laid a flooring of planks, supported on beams. Under this wooden street men worked during the day, digging away the earth and sand, and propping up the beams as the excavation proceeded.

Tunneling a city street is no simple task under any conditions. There were sewer-pipes, gas-pipes, water-pipes, electric light and power conduits, telephone, telegraph, and fire-alarm conduits, and the conduits for the underground trolley system of the electric cars, to be avoided. The gas-mains were elevated above the streets so that there would be no danger of an explosion, should they develop a leak. Of course, the manholes or underground chambers, where connections were made with the telephone-lines, had to be torn away, exposing the lead-sheathed telephone cables. To protect these cables from the picks and shovels of careless laborers, they were wrapped thickly with burlap.

A telephone lineman was down under the planking one morning, making some new cable connections. He was pouring hot, melted paraffin on the splice to drive out all

moisture before covering it with lead, when some of the oil spattered over on his fire. Before he knew it, there was a lively blaze, which caught the burlap, melted the lead off the cables, and consumed the insulation of the copper wires within. Choking with smoke and the fumes of burning insulation, the lineman staggered out of the tunnel, yelling "fire." By the time the engines came up, the planking was burning briskly, and the firemen had their troubles getting this queer blaze under control.

The fire was all out when Bill and I arrived on the scene. Pushing his way through the crowd as if he had the right, Bill led the way to the opening in the planking, and disappeared quickly down a ladder. I ran down after him into the charred subway. It took several moments to adjust my eyes to the twilight below, and then the sight that met them was appalling. There were thousands and thousands of copper wires burned, torn, and fused together, and matted with splashes of lead, all mixed up in the worst snarl imaginable. How could such a tangle ever be straightened out? Did we but know it, hundreds of subscribers, at that very moment, were frantically rattling their receiver hooks, shouting for "central," threatening to report those stupid telephone operators, and sending by messenger to have their "pesky 'phones" attended to.

Already there was a force of men at work trying to repair the damage. First they cut away the snarls, and then they tested each pair of wires individually. A telephone circuit always consists of two wires twisted together, and so it was

easy to tell which two wires belonged to each other. Nevertheless, it was important to test each wire of a pair, to make sure that it was electrically sound. In order to identify the pairs at the central station, a wire of a certain number would be grounded, and then the repairman, with a telegraph battery and relay connected to ground, would search through the wires until he found one which would make his telegraph instrument click. Then he would secure that wire in an index board, sticking it through a hole labeled with the number of the wire.

We watched this numbering process for a time, but soon grew tired. It was so monotonous and so hopelessly slow. The men thought so themselves, evidently, because, after a time, the order came to connect up the wires in any way possible, and they would be straightened out at the central station. There the cables would be cut again and the lines sorted out.

After we had been there some time, and were starting off to luncheon, I noticed that a man was watching us rather curiously.

"Hello," he said; "what are you doing down here?"

"Just looking on," I answered. "There wasn't anybody to stop us, so we just came on down."

"Well, I venture to say you never saw a sight like this before. I am sure I never did in all my telephone experience. Seven thousand wires all matted like wool! Not all telephone wires, either. We are in a general mix-up with the telegraph and fire-alarm circuits, too."

"I suppose this cripples the whole city," ventured Bill.

"The whole city? Ha, ha, ha! The whole city, did you say? There are five hundred thousand telephones here in this city. You just look at a telephone directory. That will give you some idea of the enormous extent of New York's telephone system. Do you know, we print carloads of those directories every year, and, would you believe it, they use up seven tons of ink! Why, you have no idea of what a lot of telephone wires there are buried in these streets. New York is a regular copper-mine. There are over seventeen million pounds of it and forty-four million pounds of lead in our cables."

"I suppose it is worth something, too."

"Well, I should say so; something like twelve million dollars, all told."

"It is lucky you have it all buried underground, or people would be stealing it," I remarked.

"Unfortunately, it isn't all buried. Only our city wires run in conduits, and we have an underground long-distance line running from Boston to Washington. All the rest of our wires are out in the open, and now and then some of the copper is stolen; but that doesn't happen very often now; not since our experience with the wire thieves on the Jersey meadows. I suppose you read about it in the papers last month."

We scented a good story, and urged the man to tell us all about it.

"Well, it was the most exciting time we ever had with

wire thieves. 'Cy' Hummer earned his money that trip any way," he said, laughing heartily. "There had been a gang of thieves at work on that lonesome spot for some time. They had given us a lot of trouble, and we realized that something would have to be done. We knew just about where those fellows were most liable to play their little game, so we fixed up a little game of our own to match theirs. We have a private detective that beats any you ever heard of, and doesn't cost anything like as much. It is an innocent-looking little mahogany box that we put on the line when we suspect trouble. The box contains a telegraph relay, a dry-battery cell, and an electric bell. We ran a current of electricity from Newark over one of our bare copper wires to this detector, which was placed in Jersey City. Then we knew that, if the wire was cut, or if any other wire crossed it, or if there was any meddling whatever, the alarm would go off in our Jersey City central, and immediately the news would be telephoned to the police at Jersey City and at Kearney. At each place there was an automobile standing ready to make a dash upon the thieves and head them off, no matter in which direction they tried to escape. We had some trouble in getting an automobile at Kearney, but a friend of mine finally located a farmer near by who had an old touring car. I went around with him to make the bargain. Cy Hummer, his name was, and he was a typical hayseed, a long, lanky fellow, chewing a straw when I saw him, just the kind of a chap that you see in the comic papers, but the queerest combination of nerve

CONNECTING UP A TANGLE OF WIRES BACK OF THE RELAY BOARD.

THERE WAS A STEADY HUM LIKE THE DRONING OF BEES.—See page 251.

and timidity I ever ran up against. I didn't believe that he could run a car until he took us out for a spin. Well, sir, the way he spun us around corners on two wheels, shot into town, dodged around the traffic, and then raced back to the farm at a fifty-mile clip, running down two hens and a stray dog, all the time chewing away at that straw as if he had nothing more exciting on hand than feeding the hogs—all that, I say, took my breath away, and when I staggered out of the back seat of that vehicle, I went up to him, and said, 'Mr. Cyrus Hummer, let me shake your hand. You certainly understand your business, and I must have you for this job. I will pay you eight dollars a night to stay with your rig at the police station, ready to take them out the instant you get the alarm, and while you are out on the job, you will get four dollars an hour extra.' You should have seen Cy Hummer's eyes open at the prospect of such wealth. 'B-b-but, the thieves,' he sputtered. 'Oh, you need not worry about them,' put in my friend. 'The police will take care of them. All you need do is to drive the car. You'd better take the job, Cy; it's the easiest money you will ever see.' So Cy took the job, and he was there every night puttering about his machine for about two weeks. Then, about two o'clock one morning, on a particularly dark night, the alarm went off. Immediately our operator notified the Jersey City and Kearney police, and the game was on. In less than a minute, the Kearney men were tearing full speed down the road, following the telephone wires. Cy knew every inch of that road, like a horse. It was well he did, because it was

pretty dark, and, of course, the machine carried no lights. When they had covered about two or three miles, they made out a dark object that looked like a truck wagon, up along the roadside. The next instant there was a volley of shots which smashed the wind-shield to bits, and peppered the car with buck-shot. 'Stop the car and scatter,' cried the police sergeant, but Cy had already jammed on the emergency brakes and brought the car up with such a jerk that they were all but pitched out. Then the police ran for cover, but in the meantime a second volley caught them. The sergeant got a rifle-ball in the fleshy part of his back; one of his men got a load of shot in the calf of his leg, while the other man had a clean hole drilled through the lobe of his ear with a buck-shot. As for Cy"—here the narrator had a fit of laughing—"Cy tumbled down behind the dash-board the instant he jammed on the brakes; but he was not built right for that cramped shelter. His lanky legs stuck way out over the side, and a rifle-bullet cut through his trouser legs, just grazing his shins. The crippled police answered very bravely with their revolvers; but what could their little pea-shooters do against rifles and shot-guns? In another moment, the thieves had whipped up their horses and disappeared down the road. A quarter of an hour later the other police arrived, gathered up the wounded, and helped to restore Cy Hummer to his senses. Poor Cy! They went all over him carefully to see where he was hurt but much to his astonishment the only injury they could find was a wounded trouser-leg."

"But didn't the police head off the thieves?" I asked.

"No, and I don't quite understand it. They didn't follow the telephone-line out of town, but took another road, and then when they heard the shooting, they struck back into the meadow road, but from the Kearney end. However, we are on the track of the men now. We offered a reward at once, and only the other day a farmer reported to the Jersey City police that his neighbor's boys came in just before daybreak on the morning of the shooting with the horses all covered with perspiration, and they had two shotguns with them. There was a man with them as well, who had a rifle, and, from the description, we have just about identified him as a lineman we 'fired' two years ago. We'll have them before long, and send them up the river for a term. They won't be the first, either. Those chaps have learned that it's dangerous to meddle with our lines. They are sure to be caught sooner or later. The same with our prepay stations. We used to have the cash-boxes robbed every once in a while, until we began putting in automatic alarms. Then we caught so many of the thieves that they soon gave up that kind of work as unprofitable. Some of the tricks they played were mighty ingenious."

We were anticipating another interesting story, when our new acquaintance suddenly looked at his watch.

"Great Scott! Lunch-time's almost up!" he exclaimed. "I'll have to chase out of here. Say, if you want to know something about telephoning, come around to my office. But don't turn up for a few days, until we get this mess of

wiring all straightened out," he said, handing us his business card.

Bill and I had a long argument as to how many days "a few" meant. Finally, we decided that it could not very well be less than three, and so, on the third day, we boldly invaded the office door of Mr. Burt.

"Glad to see you, boys!" he said cordially. "I'm going to take you around myself. The best place to start in is at the bottom." Mr. Burt led us out to the elevator. We stopped off at the ground floor, and went down a flight of stairs to the basement, and into the cable vault. There was nothing to see here but forty or fifty lead-covered cables.

"This is where the cables come in from the street," explained Mr. Burt, "and run to the boards upstairs. There are six hundred pairs of wires in each cable, and they are just humming with talk."

"What, those silent cables!" I ejaculated. It seemed absurd. The stillness in that vault was almost oppressive when its echoes were not disturbed by our voices and the scraping of our feet on the concrete floor.

"Yes, they are just throbbing with life—hundreds, even thousands, talking at once. You know we Americans do more 'phoning than any other people on earth. Why, last year, we held fourteen and a half billion conversations, and that is two thirds of the telephone talks of the whole world. A pretty big share of those conversations took place right here in New York. There are twice as many telephones in this city as in all of France, and nearly as many as in the

whole of Great Britain. There is a 'phone in this country for every twelve people. If only your ears were electrical, and you could hear all the electrical vibrations passing through those cables, you would find those silent lines a perfect babel of noise—a sample of every tongue on earth, from Chinese to Bulgarian, shouting and scolding, laughing and weeping maybe. Very likely fortunes are being made and lost over these wires at this very moment, for we are very close to the financial district of the city. But we are stone-deaf to it all until the electrical waves are turned into air waves by the telephone receiver. Possibly some of these lines are carrying urgent messages as far as Chicago or St. Louis, or even Denver. By the way, I just figured out last night that it takes twenty carloads of copper to carry your voice from New York to Chicago. So, you see, minutes are precious on our long-distance lines, and when wire thieves cut our wires, the interruption of business means more to us than the loss of the copper."

We stepped out of the cable vault into a room filled with coils and coils of cable and wire that reminded me of the tangle we had seen in the subway. Mr. Burt informed us that this was the wiring for the Manhattan Syndicate Building.

"We used to do all the work at the building," he said, "but now we save time and expense by making our lay-out here, and then the whole cable, with all its tap-offs, is taken to the top of the building and dropped down the cable shaft. We have it so fixed that there are the proper out-

lets at each floor, so that all the men have to do at the building is to make the connections at each office, as required. In a building like that, we have two hundred and thirty miles of telephone wiring, enough to reach from New York to Washington, and, as you can imagine, it takes some careful estimating to get the wires in just the right place."

On the third floor of the building we saw how the cables open out into myriads of wires and are connected to a perfect maze of safety devices on the distributing frames. Even here, the system was perfectly cold and silent, and it was difficult to realize the feverish activity that was throbbing through those "copper nerves," as Mr. Burt called them. The distributing frames fairly dazzled us with their complexity.

"Will it sting me if I touch it?" asked Bill, reaching his finger to one of the contacts.

He was rather daring, I thought, but Mr. Burt laughed. "Why, boy, you couldn't feel it. Don't you know that the telephone is one of the most delicate of instruments? We use twenty-four volts to force the current through the miles of wire, but the talking currents themselves are so feeble that it takes a very sensitive apparatus to find them. They are measured in thousandths of an ampere, and you know what that is, when you can get anywhere from six to thirty amperes out of an ordinary dry-battery cell."

"But I got a pretty bad shock the other day," said Bill, "when I was using the 'phone.

"That was the ringing current. Somebody was trying to ring your bell while you had your hand on the binding posts at the ends of the receivers. We have to use a more powerful current to make the bell ring, but the telephone itself is so sensitive that we have to guard against any excess of current. On this frame here we have lightning arresters, heat coils, and fuses that will melt through if too heavy a current should come over the wires, as, for instance, if any electric-light wires should happen to cross one of our wires. Over there on that frame, the wires are sorted out, arranged in groups, and connected with the switchboard above. Before we go up there, I will show you the battery room."

There, for the first time, we began to see some life. Not in the batteries themselves—they were as dead as all the rest of the system—but in a frame alongside, in which there were hundreds of little can-like boxes; "line and cut-off relays," Mr. Burt called them. They were clicking one after the other, here and there, all over the frame. Mr. Burt explained that these relays switched in the extra current to light the signal-lamps at the switchboard.

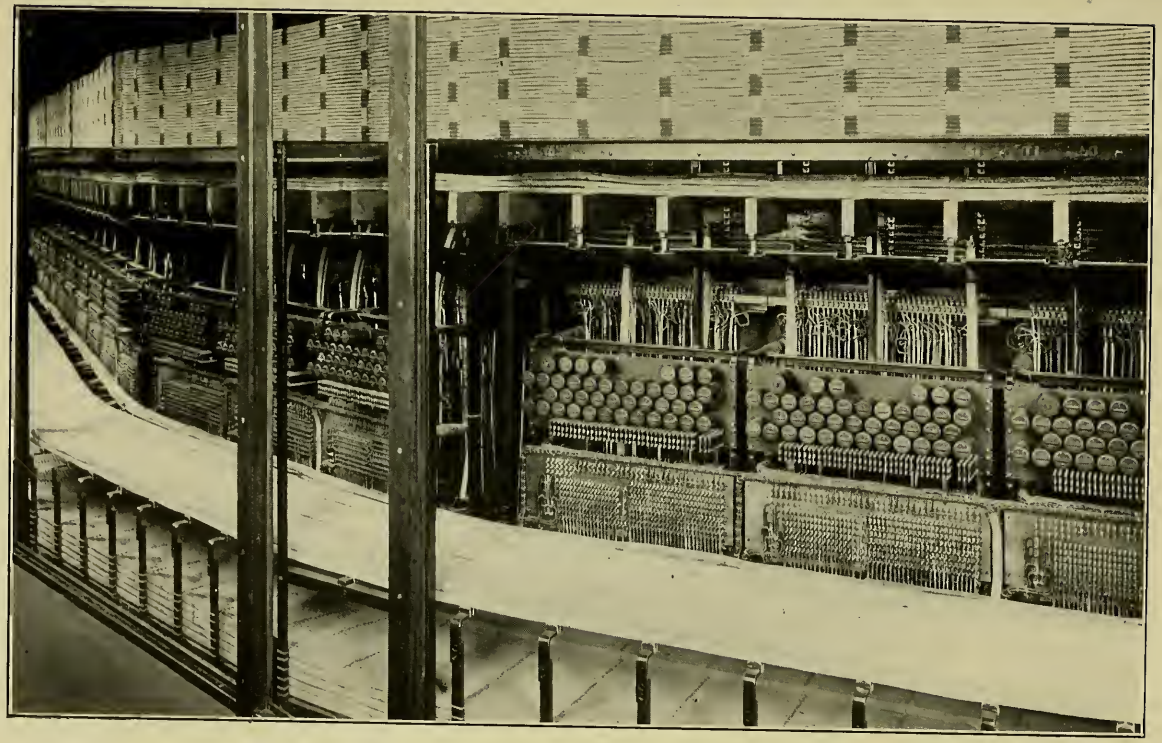
"Now for the switchboards," said Mr. Burt, "the most interesting part of all," as he led the way to the floor above. When he opened the door, I imagined he had taken us into a beehive. There was a steady hum, like the droning of bees. It took me a minute or two to realize that the noise was the talking of scores, yes, hundreds of girls. We couldn't see them all at once, because the room was shaped

like a ⊏, but as we walked on around, we found that the entire outer wall was lined with switchboards before which the girls were seated on high stools so close to each other that they nearly touched elbows. Each one had a receiver at her ear and a horn-shaped transmitter hanging before her mouth. That left both hands free to work, and those hands were certainly busy, picking up "plugs" on the ends of cords and sticking them into holes in the board in front of them. The cords were criss-crossed all over the board, while colored lights flashed up here and there, and, above all, that droning sound. If you stopped to listen to any particular girl, you could hear her saying, "Number, please," "Audubon 12953, Cortland 10476," "Line is busy," etc.

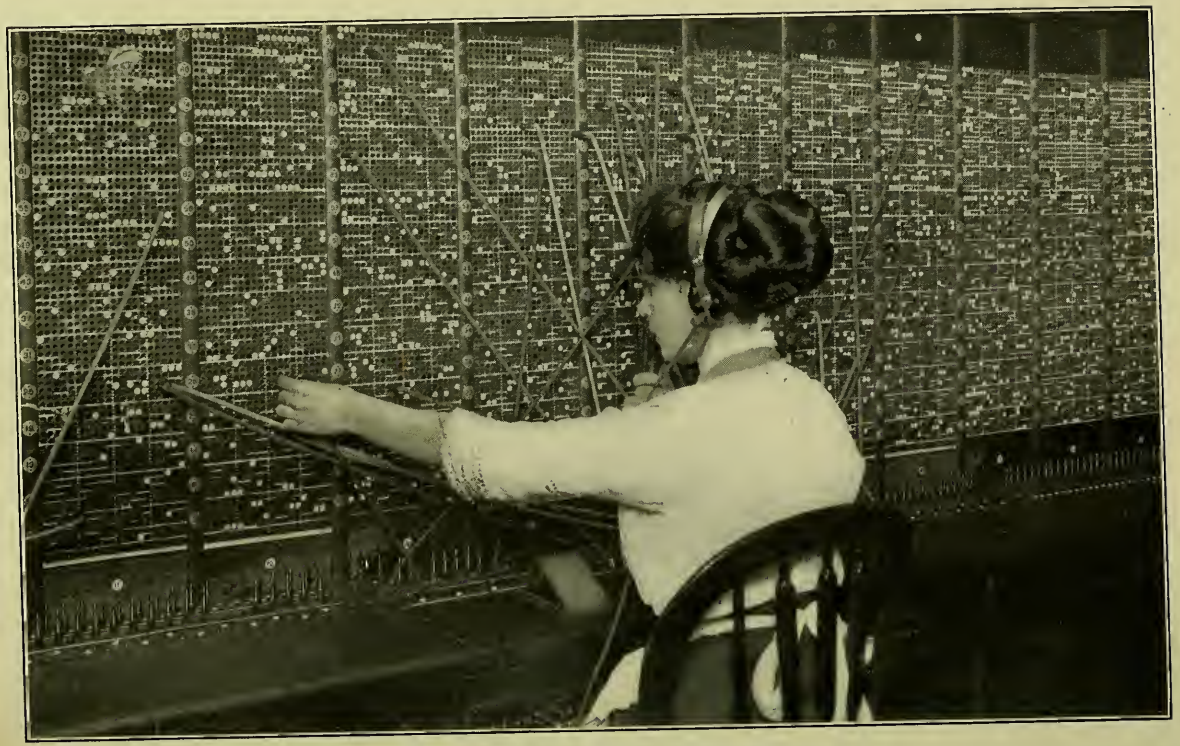
"Looks pretty complicated, doesn't it?"

"Well, rather," I exclaimed. "I can see that it would take a week of hard study to understand it all."

"But it is really very simple, you know," said Mr. Burt. "If you could only forget that there are thousands of circuits here, you would understand it very readily. It is the repetition that makes it seem so complicated. Now, this switchboard is divided into two parts. We call one the 'A' board; it takes up about two-thirds of the room, and the other is the 'B' board. Suppose you were a subscriber connected with this central, and wished to call up some one also connected with this central. As soon as you took your receiver off the hook, a lamp would light up somewhere on the 'A' board, and any one of three or four girls who were



THE BACK OF A SWITCHBOARD LOOKS EXCEEDINGLY COMPLICATED.



TEN THOUSAND "JACKS" WITHIN HER REACH.

nearest that lamp would put a plug on one end of a cord into the 'jack' of your circuit, and say, 'Number, please.' As soon as she received the number, she would put the plug on the other end of the cord into the jack, or hole, of the number you called. Now, that is simple enough, isn't it? You see, she has within her reach the lines of all the subscribers of this central station."

"But suppose I wanted a subscriber in some other central?"

"All right. Say you wanted five thousand and something Murray Hill. Your 'A' operator would repeat the number to a 'B' operator at Murray Hill. The 'B' operator would tell the 'A' operator to use trunk line No. 8, we'll say, and then would put the plug on the end of that trunk in the jack, or hole, bearing the number you called for."

"Do you mean every girl has five thousand of those holes, or 'jacks,' as you call them, within reach without leaving her chair?"

"Yes, ten thousand. In each panel there are seventeen hundred jacks, and each girl can cover six panels by reaching across her neighbors. The panels in sets of six are repeated many times all along the 'B' board, so that every 'B' girl has access to every subscriber of her central station."

"It isn't so very hard to understand, after all," I admitted.

"I thought you would find it simple, and it's quick, too, isn't it? In Paris, not long ago, a record was made of the time it takes to call up a subscriber, and the average was

found to be 1 minute 20.8 seconds. Here in New York the average is eleven seconds! It takes training to do that. We have schools for the girls, and we pay them while they are learning the trade. We have schools for boys, too, who want to go into the telephone business. When you graduate from college, you had better come around. We pay students well while training them."

Bill was interested at once, and asked all sorts of questions, but as for me, I kept quiet. I wasn't going to college. I had no rich Uncle Edward to help me out.

CHAPTER XXIV.

AN UNDERGROUND SWIM.

"If ye mate me at O'Flaherty's, be the fut of 158th Sthreet, at ten to-nite, i'll sho ye a bit of kason work that ye dont vary ofen see.

"Yur frind,

"DANNY ROACH."

It was a dirty piece of writing paper, scrawled over with pencil marks in characters that were well-nigh illegible, and grouped together in a brand of simplified spelling that was strictly home-made. But nevertheless we felt flattered to receive it, for in the sand-hog world, Danny Roach was looked upon as the dean of his profession.

"Say, old man," said Bill, "there must be something pretty important doing, or Danny Roach would never bother to write. I'll bet you we get a fine story for the *Sphere.*"

We found the rendezvous without much difficulty. It was a dreadful night, pouring "daggers and doornails," and the brightly lighted saloon was the only cheery spot in the neighborhood. But it was a rough place, and looked far from inviting when we opened the door and found it filled with a noisy, boisterous gang, drinking foul stuff, smoking foul stuff and using foul language. Danny Roach was at

the bar. Several scars on his face showed clearly the price he had to pay for running through fire under pneumatic pressure.

"Come on in b'ys," he called when he caught sight of us. "Glad to see yez. Wad yez have a glass wi' me? Pwhat, not aven a glass o' beer. Thot's right, b'ys, thot's right," and he proceeded to give us the best temperance lecture I have ever heard.

"Why do you drink, then?" queried Bill. Danny Roach dropped his left eyelid slyly, and said, "Ye wadn't deny an auld man his glass now and thin."

He finished his drink, and we all sat down at a table in the corner, where he explained to us what was up. He told us that he was working on the caisson for an open shaft. They had an accident there a few days before. The shaft had been driven down to the rock, but the rock was seamy and they had to blast it out to a considerable depth in the endeavor to get a water-tight seal. The constant blasting had done much damage to the deck. The timbers were torn in splinters by the chips of rock fired against them with each explosion. The deck was considerably weakened and was not holding air very well. Unlike other caissons we were accustomed to there was no solid cement filling above the deck because the shaft was to be left open. Water was used instead, and through it the air from the working chamber bubbled freely. A man was set to work stopping the leaks with clay and oakum. He was a greenhorn, and when he heard the hissing noise of escaping air he moved

the candle near the spot to find the leak. Immediately the air sucked the candle flame into a long tongue that licked through the crevice, setting fire to the deck. Utterly oblivious of the mischief he had done, the fellow kept on puttying up the holes, now and then starting a new blaze, until of a sudden a danger signal sounded, "rat-tat, rat-tat, rat-tat-tat." When the men got out, they found a volume of heavy smoke pouring from the caisson.

There was nothing to do but to drown out the fire by stopping the air pumps. Presently the water above the deck began to settle rapidly, showing that the fire had burned through the timbers. The fire was soon quenched, but that was only the beginning of the trouble. The problem then was to get the water out. The compressors made little impression, for the holes in the deck were so large that air leaked out as fast as it was pumped in, the shafting was blown clear of water, and the water was forced down a few inches below the deck of the working chamber, but no matter what they tried to do they couldn't clear any more of the caisson.

"They've jist about given up in dishpair," said Danny Roach. "Last night O'Connell, the Superintindint, he tuk a lot av rats and thried to git thim to turn the thrick for 'im."

"What's that!" we cried in amazement.

"Yis, rats, Oi said. He had a dozen av thim. 'Danny,' sez O'Connell, "tis a great plan I have,' he sez. 'We'll thurn the rats loose and lit thim foind the holes fur us.'

Oi had the plisint job av holdin' thim cratur's be the heads with a thowel, whilst he tied a bunch av o-akum to ivery tail. Thin we tuk thim bastes down into the shafting wi' us and dhropped thim into the wather. Yez ought to seen thim rats shtrike out. They wint off loike Noah's dove, lookin' fur land, and dirictly foindin' none they made back fur the ladder. That's where our fun came in. Iviry toime a rat cam' near, we wad kick him back ag'in. It was great shport for a whoile. Thim rats was foine swimmers. 'Look here, O'Connell,' Oi sez, 'Yur rats won't do the thrick for ye. We're just drowndin' thim.' 'Let thim drown, thin,' he says. 'We can't carry thim out.'

"All of a suddint ivery one of thim rats disappeared, ivery mither's son av thim. They had been comin' up wan at a time, jist as nice as ye plaze, so we cud dhrive thim away agin widout inconvanience. But ye can't git ahead of a rat. There's not a woiser cratur' aniwhere. Thim rats got togither and hild a council av war, so to shpake, and thin desoided to rush the ladder. They came from all soides to wancet. Belave me, if ye niver faught a rat, ye don't know how thim divils kin foight. We couldn't shtop thim. We didn't have a shtick or anythin', only our boots. But four boots and only two of thim workin' at a toime gin twelve rats was no match at all. We both kicked for all we wuz worth, till O'Connell fell aff the ladder into the wather. The bist we cud do was to kill foive of thim. The rist av thim run up over us fittin' and snappin' and on up a rope so fast we couldn't shtop thim.

" 'Will, now yu've done it, O'Connell,' Oi sez. 'How are ye goin' to git up?' He was cussin' so hard he couldn't answer me. Oi saw there wus only wan thing to do, and so Oi done it. Oi climbed up to the lock, expectin' thim rats to jump down on me any minit. Thin Oi histed up the door, shut me rats in the lock, knockin' the while fur Tim, the lock-tender, to lit thim out. He didn't know we had rats in the bag we tuk down wi' us, but Oi'd loike to have seen Tim's face when he opened the lock, expectin' to see me own sunlit face, whin sivin wet rats as big as Tom cats, jumped out at him, each wi' a bunch av oakum dhraggin' behoind. It was sich a shock, that he run aff fur help, and tawld the ither men how sivin divils had drownded me and O'Connell and thin changed thimselves into rats and flew aff whin he opened the lock. It was an hour before we cud git anywan t' come near enough to answer our signals, and lit us out. O'Connell was pretty badly bit up and he's aff dooty to-night. Oi got a few scratches mesilf." He pointed to several ugly wounds on his neck and arms.

"Now I have some schemes av me own, only Oi want somebody width brains to hilp me. Oi'd loike to have Bill tind to the lock, and Jim, you kin come down width me and we'll see ef we can't fix up the throuble."

Bill didn't like this arrangement at all, and said so very emphatically. Finally it was settled that he was to go with us while Larry Doogan tended the lock.

"Larry's got some brains," admitted Danny Roach, "and he ain't afraid av spooks."

It was after eleven when we got to the shaft. Danny hadn't told us what he was going to do, but presently we had a hint. When we got into the lock he removed his clothing and hung it on a projecting bolt.

"You're not going to swim around down there," I said in some alarm.

"Shure, and whoi not? If the rats cud do it, Oi can, and Oi have brains, which they haven't."

"But the dead rats," I said.

"Oi'd rather have thim dead than aloive."

"Well, you're welcome to the job," said Bill. "You don't want us to go in, too, do you?"

"Oh, no," he said. "Yez can hand me the clay and the o-akum as Oi need it."

We insisted on tying a rope to him and holding the end so that we could haul him in if necessary. We went down the ladder to the bottom of the shafting. The electric lights were out of commission and we had to use a candle. We could see by its uncertain light the black water fairly boiling with the air that was forced through it. The water was actually within four inches of the deck. How anyone had the nerve to swim under there in the dark with only four inches of breathing space, was more than I could comprehend. Just then Danny plunged in. In a moment he came up again, treading water. "Come on in, the wather's foine," he said.

"Not on your life," I answered, and I meant every word of it. "The pleasure's all yours."

"Gimme a lump of clay," said Danny. Then, swimming on his back, he disappeared under the black deck, his head almost scraping the timber. I held the candle close to the water to give Danny at least a flicker of light, at the same time taking care to keep it clear of the oakum we had on hand. I caught sight of a dead rat floating in his wake. The sight was grewsome. We uttered not a word, but listened in breathless suspense. Then we heard Danny chuckle, and in a moment he was back again. "Gimme some more clay," he cried.

"Did you stop any leaks?"

"Shure," he said. "Ye nadn't use that candle. I don't nade the light. Candles and oakum ain't good company down here."

He disappeared a second time under the black ledge, only to re-appear pretty soon with a call for a "big wad av o-akum." He had found a large opening.

After a number of trips Danny stopped to rest. Then we noticed that the water was actually beginning to subside. Encouraged by this success Danny resumed his work with redoubled energy, dispensing with the life rope, which, very evidently, was doing him no good.

The result of his efforts were now readily apparent. The water was receding rapidly. Soon it had dropped three or four feet, uncovering a cross brace in the caisson, upon which we climbed out and assisted in the work of stopping the holes. After nearly an hour's work our task was done. The rock bottom was bared, and we climbed up the shaft-

ing, congratulating Danny Roach upon the success of his brave venture. Danny was glad enough to get dry clothing on, and for once he went directly to the sandhog house, where he wrapped himself in blankets and drank hot coffee to guard against the chill he had been exposed to.

As for me, I went to the telephone and called up the Night Editor of the *Sphere*. The story I told was such a thriller that he had me dictate it right over the 'phone, and held the presses to get it into the first morning edition.

CHAPTER XXV.

IGNITING OIL BY COMPRESSION.

THE powerful sea-going tug *Champion* was well under way before Mr. Price finished greeting his many friends on board and turned to us. We had received a last-moment invitation from him, by telegraph, to join the party of engineers who were going down the bay to meet the new ship, *Christian X.* Why the vessel should receive such attention we hadn't the least idea, but that did not deter us from accepting the invitation with alacrity, and here we were, patiently waiting for a chance to question our host.

"Why, it's a Diesel-engined ship, the first to visit this country," he replied, in answer to Bill's query. "I suppose your Uncle Edward has told you all about Diesel engines?"

Bill shook his head.

"What! Didn't he tell you anything about them? Why, one of the principal objects of his visit abroad this year was to make a study of these new engines. That was why I asked you to join our party. It just occurred to me this morning at breakfast, and I sent James out with the telegram at once."

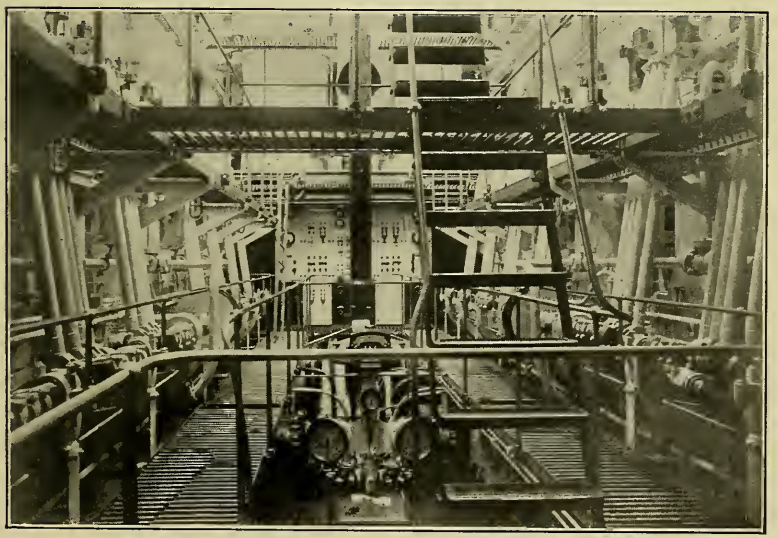
"It was awfully good of you," said Bill, "and we are both anxious to see that steamer, but we don't know anything about her engines."

"Well, I should say you didn't, or you wouldn't call her a steamer," answered Mr. Price. "She doesn't use steam at all. A Diesel engine is something like an automobile engine, only it burns oil instead of gasolene. You know how a gasolene engine works, I suppose? First the piston moves out, sucking into the cylinder a charge of mixed gasolene vapor and air; then the piston comes back, compressing the charge; then a spark ignites the gasolene, exploding it so that it drives the piston out again; and, finally, as the piston moves in once more, it forces out of the cylinder all the gases formed by the burning of the charge; after this, the process is repeated. That is what we call a four-cycle engine, because it takes four strokes of the piston to complete the cycle of operation. Only one of the four strokes is a working stroke."

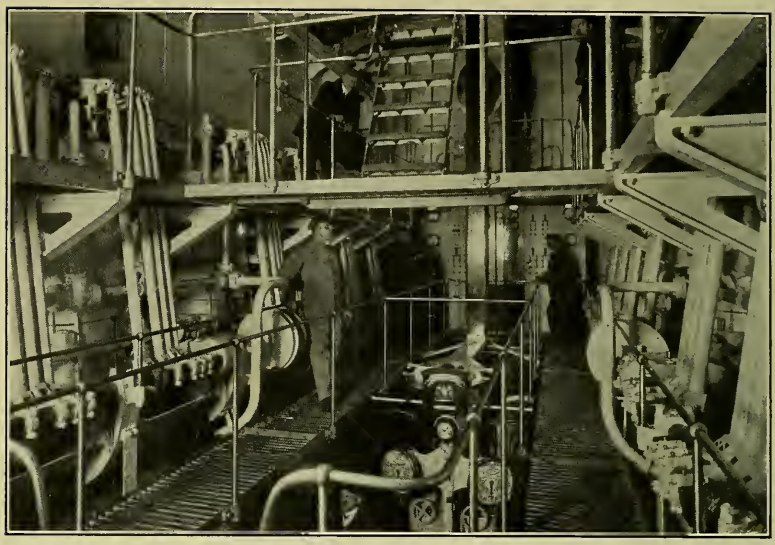
"But what keeps the engine going between strokes?"

"The momentum of the fly-wheel. It is as if you had one pedal on your bicycle, and you made the machine go by giving the pedal a kick every other time around. Usually the engines are built with a number of cylinders, the pistons of which are set to work one after the other. In a four-cylinder machine, there is a kick by one or another of the four pistons at each stroke. The main trouble with the ordinary gasolene engine lies in getting just the right mixture of gasolene and air into the charge, and in igniting it with a spark; but in the Diesel engine, cheap oil is used instead of gasolene, and it is ignited without any spark or flame. How, do you suppose?"

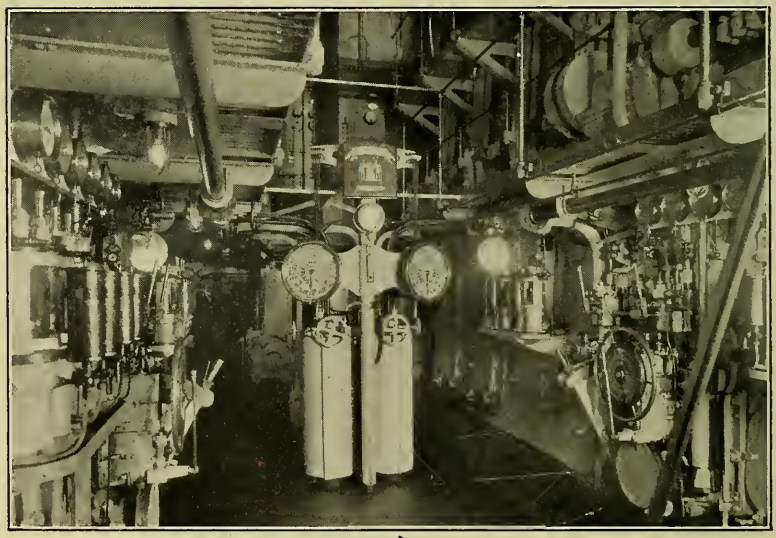
"WHY, IT HASN'T ANY SMOKESTACKS!"—See page 266.



ENGINE ROOM OF THE "CHRISTIAN X."



THE GALLERY IN THE OIL-ENGINE ROOM OF THE "SELANDIA."



LOWER DECK OF THE "SELANDIA'S" DIESEL ENGINE ROOM.

We couldn't guess, of course.

"It's like this: on the first downward stroke, pure air is drawn into the cylinder, then the piston rises and compresses that air to nearly five hundred pounds per square inch. You know that when you compress air it gets hot?"

"Oh, yes," I chimed in; "don't you remember, Bill, how the paint was all blistered off the air-compressors at the aqueduct plant?"

"Yes," continued Mr. Price, "that is right; but there the pressure was very small compared with this. Why, with five hundred pounds to the inch, the temperature amounts to one thousand degrees Fahrenheit; that is, the air gets as hot as iron when it is cherry-red. Into that 'red-hot' air a spray of oil is forced by a jet of air compressed to about nine hundred pounds per inch, and at once the oil bursts into a flash of flame, kicking the piston out with a powerful stroke. The next stroke clears the cylinder of gases."

"But why doesn't the jet of air set the oil on fire?"

"Because it comes from a storage tank, and is cooled before it is stored."

"What I can't understand is why they don't lose a lot of power when they compress the air in the cylinder," put in Bill.

Mr. Price laughed. "I knew you would ask that; every one does. The pressure in the cylinder cannot get away. The work the piston does in squeezing that air is not lost, but is all given back to it on the next stroke, and, in addition, there is the pressure of the exploding charge. There is some

loss in the compressed air that sprays the oil into the cylinder, but the loss doesn't amount to very much."

"What's the advantage of an oil engine? I should think coal would be cheaper."

"Do you know how much power is wasted by steam-engines? Ninety per cent! Why, if they could employ all the energy in the fuel, they would feed the furnaces with coal by the lump instead of by the shovelful. With these oil motors, the wasted energy is cut down to about sixty per cent. The *Christian X* has two motors, each of twelve hundred and fifty horse-power, and they use one third of a pound of oil per horse-power every hour, while a steamship would use more than a pound and a half of coal. They save one hundred and thirty dollars a day. Then there is another advantage: it is a tedious and dirty job to coal a ship, but the oil-motored ship is loaded with fuel by means of a pump, and the oil is stored in the double bottom, where it takes up no cargo space. Then, too, there is no boiler-room, which provides more space for the cargo, and does away with a lot of the crew."

He was interrupted by a commotion forward. Some one had sighted the *Christian X* at anchor at Quarantine.

"What makes it look so queer?" asked Bill. "Why, it hasn't any smoke-stacks!"

"Now, why should it? There is no furnace on board, and no smoke comes from the engines. That is a feature of the oil motor that would count for a great deal in a war-vessel that did not want to betray its presence to the enemy."

By the time we reached the *Christian X*, the health officers had examined the men on board, and we were free to visit the ship. No sooner had I scrambled up to the deck, than some one seized me by the coat-collar, and demanded, in a gruff voice:

"Young man, what are you doing here?"

Without waiting for an answer, he dropped me and grabbed Bill, who was right behind me, and dragged him up on the deck.

We both gasped in astonishment—it was Uncle Edward!

"W-w-where did you come from?" stammered Bill.

"And w-w-where did you?" mimicked Uncle Edward. "The surprise is mutual. Dr. McGreggor and I are about the only passengers on board. We have been studying the motor engines all the way across, and they have behaved beautifully. But how in the world did you happen aboard?"

While we were in the midst of our explanations, Uncle Edward caught sight of his partner.

"Oh, McGreggor," he called, "see who's here. These are the two chaps you thought would go to the dogs if they were turned loose in New York. Here they are, keenly interested in Diesel engines, and during the last few months they have been through almost everything of any engineering importance, I hear. You must admit that my confidence in these youngsters was not misplaced."

"Wait a bit; let me cross-examine them," returned Dr. McGreggor. "How much of that one thousand dollars is left?"

"Quite a little," said Bill, pulling out his check-book, which showed a balance of about $480.

"Some of it was spent at Coney Island?"

"Oh, yes, some; I couldn't say how much. You know, we have had a very hot summer."

"What else have you seen?"

"Bridge-building, foundations, the aqueduct——"

"Hold on, now; what evidence have I of all this?"

"Our diary. Jim is the scribe, you know. He has an account of everything of any importance. He took notes as we went along, and then entered them in the diary at night. He has written some articles for the *Evening Sphere* that brought us in quite a lot of money."

"Where is your note-book, Jim?" asked Dr. McGreggor, sternly.

I handed him the book, apologizing for its scrawly condition. He looked at it perfunctorily at first, then an item caught his attention, and he began to examine the notes intently.

"Well?" interrupted Uncle Edward, after we had waited for several minutes.

"Most interesting," muttered Dr. McGreggor, "most interesting. Young gentlemen, I have no case, and I shall direct the jury to bring in a verdict in your favor."

"Hurray!" shouted Uncle Edward, patting Bill on the back; "you have the right stuff in you; I knew you wouldn't fail me." Dr. McGreggor shook his head, and grunted something as Uncle Edward continued, "Bill, I am going to

put you through a stiff course in college, and make an engineer of you."

Bill was radiant.

Then a most unexpected thing happened. Doctor McGreggor spoke up. "Jim is going through college, too, and I am going to meet his expenses."

I was overwhelmed. A college course for me! How I had longed for it. How impossible it seemed with father in his present straitened circumstances! How it had hurt to think of Bill's going to college while I stayed at home, for I felt certain all along that his Uncle Edward would look after him. I don't know that I comported myself very creditably, but I stammered out some sort of thanks —not a thousandth part of what I felt.

"I was planning to take care of Jim, too," said Uncle Edward. But Dr. McGreggor insisted on bearing the expenses himself. After he and Uncle Edward had talked it over at some length, it was finally conceded that Dr. McGreggor should see me through college, provided my parents did not object.

"Hello, we are under way again," exclaimed Uncle Edward, "we had better run below, or the ship will be docked before you have a chance to see the engines running."

Of what we saw down in the engine-room I have only the vaguest impression. The accompanying photographs will tell the story better than I can. My eyes could not take in very much, for my mind was up in the clouds somewhere.

THE END.

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